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PATENT ABSTRACTS OF JAPAN

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) SUPER-FINE CONDUCTOR FOR WINDING, AND ITS MANUFACTURE

)Abstract:

ϽBLEM TO BE SOLVED: To provide a conductor excellent in electric conductivity, tensile strength, wability and coilability by containing foreign matters of specified diameters in a super-fine conductor taining Ag of a specified ratio, and the balance Cu with inevitable impurities.

LUTION: Ag of 1-4.5 wt.% is contained, and the diameter d (μm) of foreign matters is expressed by the nula d=0.63D+0.13, where D is the diameter (μm) of a super-fine conductor. In a manufacturing method he super-fine conductor in which a copper alloy cast ingot preferably containing 1-4.5% Ag and the ance Cu with inevitable impurities is cold rolled, the cast ingot is cold rolled with the working ratio of ≥ 997% so that the dendrite arm space of the casting structure is ≤15 μm, and Ag crystal is uniformly persed with the diameter of ≤15 μm, or annealed at the temperature below the re- crystallization perature during the cold rolling. The total working ratio can be increased to provide a super-fine ductor and to increase the size of a stock material.

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im(s)]
im 1] the remainder consists of Cu and an unescapable impurity, including Ag one to 4.5% of the weight (it is after written as %) -- super-thin -- a conductor -- it is -- the above -- super-thin -- a conductor -- the object for coils acterized by the path of the foreign matter contained inside being below dmum -- super-thin -- a conductor /ever, d=0.63D+0.13 (the inside of a formula and D are super-thin path mum of a conductor)
im 2] cold working is performed to the copper alloy ingot which the remainder becomes from Cu and an ;capable impurity, including Ag one to 4.5% -- super-thin -- the object for coils according to claim 1 to which it is nanufacture method of a conductor and 15 micrometers or less and Ag crystallization object are characterized by he aforementioned ingot distributing uniformly [the dendrite arm space of a cast structure] in a diameter 15 ometers or less, and performing the aforementioned cold working by 99.997% or more of working ratio -- super- -- the manufacture method of a conductor
im 3] cold working is performed to the copper alloy ingot which the remainder becomes from Cu and an ;capable impurity, including Ag one to 4.5% -- super-thin -- the manufacture method of a conductor -- it is -- the ementioned ingot -- the dendrite arm space of a cast structure -- 15 micrometers or less and Ag crystallization ct -- a diameter 15 micrometers or less -- uniform -- distributing -- the aforementioned cold working -- on the way - : object for coils according to claim 1 characterized by being alike and annealing at the temperature of under a ystallizing temperature -- super-thin -- the manufacture method of

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ΓAILED DESCRIPTION

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tailed Description of the Invention]

ↄ1]

e technical field to which invention belongs] the object for coils which this invention is used for the coil of :tronic equipment carried in the back light transformer of the vibrating motor for the stepping motor for clocks, the ʒnetic head of an audio video or a voice coil, a cellular phone, or pocket bells, various micro relays, a personal ıputer, or television or a flyback transformer, and an automobile, and is excellent in conductivity, a mechanical ɔerty, wire drawing nature, coil nature, etc. -- super-thin -- it is related with a conductor and its manufacture method

ↄ2]

scription of the Prior Art] the object for coils -- super-thin -- a conductor is orthopedically operated by the magnetic after enamel covering etc. Although the tough pitch copper (TPC), the oxygen free copper (OFC), etc. are used for material, it is easy to disconnect these material in wire drawing or coil processing for low strength. If an open :uit arises, a continuous wire drawing machine will be stopped, an open-circuit portion will be removed, the time . effort of setting a wire rod to a dice and setting through and a dice to a wire drawing machine is required, and ductivity is injured. Moreover, if an open circuit arises, the defective by the shortage of a unit length will increase. reover, if wire drawing is performed through day and night and it disconnects at the night of a perfect non-human ly system, a wire drawing machine will stop till the next morning, and productivity will fall sharply. Therefore, the .lity conductor which is excellent in the wire drawing nature in which a continuation wire drawing is possible for 24 ırs is demanded. a miniaturization and lightweight-izing of recent years and electronic equipment -- following -- 20 :rometers or less -- super-thin -- although a conductor came to be required, incidentally, the amount of wire wings when carrying out the continuation wire drawing of the conductor of the diameter of 20 micrometer the speed 400m/for 24 hours is 1610g, and when the safety factor is taken to 10%, the wire drawing nature of 1800 g/Br is :ded furthermore, a path is about 20 micrometers -- super-thin -- since a conductor fractures by the tension of several ʒ, it disconnects by delicate change of a backward tension in an automatic winding machine In a manual winding chine, operation takes skill and there is a problem that it is inferior to productivity again.

ı03] the object for coils since it is such -- super-thin -- the Cu-Ag system alloy which is excellent in intensity and ıductivity as a conductor -- a close-up of a conductor was taken and the proposal of the following ** - ** was made :il now However, in order that all may multiple-times need elevated-temperature annealing, including expensive Ag much, there is a problem in respect of cost and productivity. namely, the object for coils which prevented the open cuit by the lubrication action of Ag which carries out pickling removal of the copper alternatively from the wire rod ınt face of the copper alloy which contains **Ag 5 to 15%, raises surface Ag concentration, performs repair of a face blemish, and covering of a foreign matter by Enrichment Ag, and is further rich in ductility -- super-thin -- a nductor (JP,7-96321,A) ** the object for high magnetic field generating for magnets which made the copper alloy ıich contains Ag 15 to 30% the cylindrical ingot of a minor diameter by the continuous casting process, and skipped : process of hot forging and facing -- a conductor (JP,6-93398,A, JP,6-93399,A, JP,6-103809,A) ** The path which : copper alloy ingot which contains Ag 15 to 30% was processed at 95% or more of working ratio, and it annealed ·ath], it cold-worked [path] at the temperature more than a recrystallizing temperature after that, and recovered ɔngation and conductivity is the conductor (JP,6-93398,A) of 0.1 or more mm. ** The conductor about [of having t in annealing at the temperature more than a recrystallizing temperature, having cold-worked the copper alloy ingot ıich contains Ag 15 to 30%, and having recovered conductivity] the diameter of 0.9mm (JP,6-93399,A). ** The nductor of the diameter of 0.1mm which processed the copper alloy ingot which contains Ag 15 to 30% by 95% or ɔre of working ratio, and annealed and cold-worked at the temperature more than a recrystallizing temperature after ıt (JP,6-103809,A). ** the metal mold of the copper alloy which contains Ag two to 2.8% -- the object for the

ıarine cables of the diameter of 0.65mm which solution treatment of the ingot was carried out, the multiple-times of the aging treatment was carried out to wire drawing after that, and intensity was raised, and omitted the :orcement iron braid of a cable -- a conductor (JP,48-44798,A)

ı4]

blem(s) to be Solved by the Invention] Then, this invention person etc. inquired wholeheartedly about application .e coil of the copper alloy containing Ag, clarified the addition of Ag suitable for wire drawing nature and coil re, advances research about the tolerance limit of the cast structure which is further excellent in wire drawing re and coil nature, and foreign matter size etc., and came to complete this invention. the object for coils this ntion excels [object] in conductivity, tensile strength, wire drawing nature, coil nature, etc. -- super-thin -- it aims :fer of a conductor and its manufacture method

ı5]

ans for Solving the Problem] as for invention according to claim 1, the remainder consists of Cu and an ;capable impurity, including Ag one to 4.5% of the weight (it is hereafter written as %) -- super-thin -- a conductor is -- the above -- super-thin -- a conductor -- the object for coils characterized by the path of the foreign matter ained inside being below dmum -- super-thin -- it is a conductor However, d=0.63D+0.13 (the inside of a formula D are super-thin path mum of a conductor)

)6] It is the manufacture method of a conductor. invention according to claim 2 performs cold working to the ɔer alloy ingot which the remainder becomes from Cu and an unescapable impurity, including Ag one to 4.5% -- ɛr-thin -- the aforementioned ingot the object for coils according to claim 1 to which the dendrite arm space of a structure is characterized by for 15 micrometers or less and Ag crystallization object distributing uniformly with a neter 15 micrometers or less, and performing the aforementioned cold working by 99.997% or more of working) -- super-thin -- it is the manufacture method of a conductor

)7] It is the manufacture method of a conductor. invention according to claim 3 performs cold working to the ɔer alloy ingot which the remainder becomes from Cu and an unescapable impurity, including Ag one to 4.5% -- ɛr-thin -- the aforementioned ingot the dendrite arm space of a cast structure -- 15 micrometers or less and Ag .tallization object -- a diameter 15 micrometers or less -- uniform -- distributing -- the aforementioned cold working ı the way -- the object for coils according to claim 1 characterized by being alike and annealing at the temperature nder a recrystallizing temperature -- super-thin -- it is the manufacture method of a conductor

)8]

ıbodiments of the Invention] as for this invention, the remainder consists of Cu and an unescapable impurity, uding Ag one to 4.5% -- super-thin -- a conductor -- the path of the foreign matter contained inside was specified ɔw to dmum, and wire drawing nature and coil nature were raised -- super-thin -- it is a conductor However, .63D+0.13 (the inside of a formula and D are super-thin path mum of a conductor)

ıis invention, Ag of an alloy element is super-thin, without distributing in the shape of a staple fiber, and reducing ductivity not much -- the intensity of a conductor is raised, with wire drawing nature and coil nature are improved ess than 1%, the reason for specifying the content of Ag to 1 - 4.5% is because material cost becomes high, in ductivity's falling, if it is not fully improved but the aforementioned wire drawing nature and coil nature exceed %. 1.5 - 4% of especially the content of Ag is desirable.

09] The convention of the aforementioned diameter of a foreign matter was made based on the next experiment. nely, by being made from the rough drawing wire (diameter of 8mm) of the Cu-2%Ag alloy manufactured by the R formula continuous casting machine, wire drawing of this was carried out to the conductor of the diameter of 100-micrometer, and the size of the foreign matter which remains in the fracture surface of the conductor disconnected at t time was measured with the scanning electron microscope (SEM). The path of a foreign matter is 13 micrometers nore in the conductor of 63 micrometers or more and the diameter of 20 micrometer at the conductor of the diameter 100 micrometer, and and the diameter d of permission of the foreign matter in the conductor of Path D it is shown in wing 1 -- as -- d=0.63D+0.13 being expressed with (1) formula -- clear -- carrying out -- this -- based on (1) mula, for example, the diameter of 20 micrometer is super-thin -- in order to have carried out the wire drawing of the ıductor by no disconnecting, it found out that what is necessary was just to set the diameter of a foreign matter to 12 :rometers or less By another experiment, when made from the extruded material of a large-sized ingot, the same ult was obtained. Moreover, it was checked that the relation between an open circuit and the diameter of a foreign tter etc. is the same also in a tough pitch copper (TPC) or an oxygen free copper (OFC). the above super-thin in the ation of (1) formula -- the ratio of the cross section T of a conductor, and the cross section t of a foreign matter -- it nes to be shown in drawing 2 and super-thin, when expressed with a relation with wire drawing nature (the amount wire drawings until it results in an open circuit) t/T -- the area ratio (a foreign matter space factor is called hereafter) the foreign matter occupied to a conductor is super-thin -- a conductor -- when it is about 40% and a foreign matter

space.factor exceeds 40% regardless of

[0010] When the aforementioned foreign matter was identified by the X-ray microanalyser (EPMA), they were mainly nonmetallic inclusions, such as oxide particles, such as aluminum 2O3, SnO2, and CuO, and a carbide (SiC) particle. The aforementioned foreign matter is mixed from the alumina system or silica system refractory material which constitutes ** which connects the fusion furnace which mainly serves as a path until it results [from the dissolution of a copper alloy molten metal] in casting, a holding furnace, tundish, and these. In this invention, a foreign matter point out the aforementioned nonmetallic inclusion which influences an open circuit. In addition, although metal inclusion, such as Fe, Cr, and nickel, may mix from a processing fixture etc., these cannot cause easily an open circuit by most o the small thing whose path is about several micrometers. In the case of a flat-like foreign matter, in this invention, the shape of the shape of flat and an ellipse and the spherical of the configuration of a foreign matter are most, and in the case of the average of the maximum width and a total length over coupling faces, and an ellipse-like foreign matter, it is made as the average of a minor axis and a major axis, and the path of these foreign matters makes it an overall diameter, when spherical.

[0011] Although, as for the conductor which processed the ingot (material) cast in the large-sized facility, foreign matter open circuits occur frequently from per diameter of 100 micrometer, the ingot (material) which cast by performing the usual maintenance is processible by no disconnecting to the diameter of 30 micrometer using a small horizontal-type continuous casting facility. however, a path is [around 20 micrometers] super-thin -- in order to carry out the wire drawing of the conductor by no disconnecting, for that, a foreign matter keeps calm not only the usual maintenance but a molten metal for a long time by carrying out to below the diameter of 10 micrometer desirably below the diameter of 12 micrometer, a heavy foreign matter is made to sediment to a blast furnace bottom, a light foreign matter surfaces the surface of hot water, and the special molten metal treatment of casting a molten metal with few foreign matters of an interstitial segment is needed If it does in this way, wire drawing will become possible to the diameter grade of 17 micrometer. Since invention of a claim 2 and three publications does not perform hot working or elevated-temperature annealing, there are few opportunities for the scale to mix as a foreign matter.

[0012] the object for coils to which the dendrite arm space (DAS) of a cast structure cold-works invention according to claim 2 at 99.997% or more of working ratio using the ingot which 15 micrometers or less and Ag crystallization obje distributed uniformly with the diameter 15 micrometers or less -- super-thin -- it is the manufacture method of a conductor the reason DAS specifies the aforementioned ingot to the cast structure distributed uniformly [15 micrometers or less and Ag crystallization object] in a diameter 15 micrometers or less -- the cold-working nature of an ingot -- improving -- moreover, a conductor -- it is for a surface concavo-convex defect to decrease and for pre-insulation nature to improve it is fully destroyed and the reason for specifying the working ratio of cold working to 99.997% or more has a super-thin cast structure -- Ag crystallization object distributed in an ingot is minutely distributed in the shape of a staple fiber -- the increase of the ductility of a conductor -- coiling -- a sex -- it is for improving

[0013] DAS becomes smaller [a small ingot with a larger cooling rate] depending on the cooling rate at the time of molten-metal solidification. That is, as shown in drawing 3 , DAS is a vertical-mold continuous casting ingot. (200mmphi) SCR ingot (100x50mm) Small horizontal-type continuous casting machine ingot A (10mmphi) It becom small in order. When the size of an ingot is the same, DAS is dependent on the temperature gradient of mold. That is, the case of the ingot of a small horizontal-type continuous casting machine, DAS of the ingot A which set [cm] up tl temperature gradient of mold in 50 degrees C /is as large as 18 micrometers or more, and DAS of the ingot B which s [cm] up the temperature gradient of mold in 100 degrees C /is small at 15 micrometers or less. That is, DAS can obtain the ingot of the cast structure which 15 micrometers or less and Ag crystallization object distributed uniformly with the diameter 15 micrometers or less by enlarging the temperature gradient of mold and casting it using small mold.

[0014] cold working [in / invention according to claim 2 / in invention according to claim 3] -- on the way -- the object for coils which was alike, put in annealing at the temperature of under a recrystallizing temperature, and raised total working ratio -- super-thin -- it is the manufacture method of a conductor The effect by the aforementioned annealing is concretely explained with reference to drawing 4 below. In drawing 4 , Curve a is the work-hardening property of the copper alloy cylindrical ingot of the diameter of 15mm which contains Ag 3%. Ductility falls and wir drawing becomes impossible while processing distortion epsilon shows the maximum intensity and carries out work softening of the curve a after that by 12. epsilon becomes a working limit by 13 (22 micrometers of wire sizes, 99.99978% of working ratio).

[0015] Curve b is a work-hardening property when epsilon anneals the material of Curve a at low temperature comparatively by the I point of 8.71. The maximum intensity of Curve b is of the same grade as the maximum intens of Curve a, and epsilon at that time (epsilon 1) is increasing to 15 (5 micrometers of wire sizes, 99.999988% of

ıng ratio). The aforementioned annealing was performed by passing the inside of the annealing furnace with a h of 2m which made the interior 700-degree C inert gas atmosphere between ** the speed for 200m/. the tensile gth after annealing -- 985N/mm2 it is -- this intensity is intensity by which epsilon (epsilon 2) of Curve a is 'alent to 6, and a distortion elimination factor is 31%= [(epsilon1-epsilon2)/epsilon1 x100] The aforementioned e-strength 985N/mm2 When it applies to the static annealing softening property of drawing 5 , annealing between ** is equivalent to static annealing of 300 degree-Cx 1 hour, and is under a recrystallizing temperature. In ion, processing distortion epsilon of the material of Curve a of aforementioned drawing 5 is the static annealing ning property of the I point (wire-size 193micrometer, 99.98% of working ratio, tensile strength 1070N/mm2) of Thus, by putting in annealing at the temperature of under a recrystallizing temperature in the middle of cold ing, high intensity can be maintained and total working ratio can be raised. Therefore, a more nearly super-thin uctor is obtained, or the diameter of a material (ingot) can be enlarged, and productivity improves. the conductor h puts in annealing -- size (path) -- the wire drawing to the diameter of a target after annealing -- a conductor -- it sirable to select so that intensity may turn into the highest intensity in front of a working limit Since the mentioned annealing is performed at the low temperature of under a recrystallizing temperature, it is advantageous ergy. You may perform the aforementioned annealing repeatedly two or more times. Moreover, the direction ormed with in-line is excellent in productivity rather than it carries out with outline. An effect with the same said of annealing is acquired.

6] Curve c is a work-hardening property when epsilon (epsilon 1) anneals the material of Curve a at an elevated erature (temperature more than a recrystallizing temperature) comparatively by the I point of 8.71. For the material urve c, epsilon is 16.5 (4 micrometers of wire sizes, 99.999993% of working ratio). It has disconnected and the king strength is quite [material / of Curves a and b] a low. The material of this curve c has [that it is easy to onnect intensity with an automatic winding machine for a low reason] bad coiling nature. Although wire drawing e material of this curve c was carried out several times using various wire drawing machines, each disconnected it re and after 4 micrometers. That is, 4 micrometers is a wire drawing limitation. Whatever the material, the uctor of a wire drawing limitation should avoid use. Annealing of the material of Curve c was performed by ing the inside of the annealing furnace with a length of 2m which made the interior 1000-degree C inert gas osphere between ** the speed for 150m/. the tensile strength after annealing -- 420N/mm2 it is -- this intensity is ntensity by which epsilon (epsilon 2) of Curve a is equivalent to 0.1, and a distortion elimination factor is 99%= silon1-epsilon2)/epsilon1 x100] The aforementioned tensile strength 420N/mm2 When it applies to drawing 5 , aling between ****** is equivalent to static annealing of 500 degree-Cx 1 hour. It was checked that stallization is completed by microstructure observation.

7]

mple] An example explains this invention in detail below.

mple 1) various carries out amount combination of Ag within this invention convention at electrolytic copper, this goted with a graphite crucible, it casts in metal mold to the ingot of the diameter of 10mm, and the diameter of 20 ometer is super-thin in this ingot -- wire drawing (99.9996% of working ratio) was carried out to the conductor it obtained -- each -- super-thin -- the relation of tensile strength (TS), conductivity (EC), wire drawing nature, coil re, and wire drawing nature and coil nature was investigated about the conductor similarly super-thin [about the Ag alloy and oxygen free copper of composition this invention convention outside] because of comparison -- the ductor was manufactured and the same investigation was conducted A result is shown in the drawing 6 (b) - a (e). relation between tensile strength and Ag content was shown in the drawing 6 (b). The example article of this ntion which contains Ag 1 to 4.5% is 2 940-1150Ns/mm. It turns out that it is high intensity. As for tensile ngth, Ag falls rapidly at less than 1%. The relation between conductivity and Ag content was shown in the drawing). It turns out that the example article of this invention which contains Ag 1 to 4.5% has the high conductivity of S 88.5 to 81.5%. If Ag exceeds 4.5%, conductivity will fall under to a specification value (81.5%). The relation veen the wire drawing nature (the amount of wire drawings per one open circuit) when carrying out a wire drawing e drawing 6 (**) from 25 micrometers at 20 micrometers and Ag content was shown. It turns out that the example cle of this invention which contains Ag 1 to 4.5% has the high wire drawing nature of 1800 - 2500 g/Br. at less than , the diameter of Ag of 20 micrometer is super-thin -- the wire drawing nature of 1800 g/Br required for the 24-hour tinuation wire drawing of a conductor is not guaranteed The rapid fall of wire drawing nature whose Ag the rovement in the wire drawing nature in 1 - 3% is an effect by alloying, and exceeds 4.5% is based on the earance of an eutectic structure. The relation between coil nature and Ag content was shown in the drawing 6 (d). diameter of 20 micrometer of coil nature which carried out enamel covering is super-thin -- it expressed with the nber of times of an open circuit when carrying out coiling of the conductor with a manual winding machine or an omatic winding machine, and producing the 100 magnetic heads There is [in an automatic winding machine / in a

ual winding machine] all little number of times of an open circuit of the example of this invention which contains l to 4.5% 4 or less times at 1 or less time. Especially desirable Ag content seen from coil nature is 1.5 - 4%. They wire drawing nature (the amount of wire drawings per one open circuit), and coil nature (number of times of an ı circuit under 100 coil production) to the drawing 6 (**). The relation was shown. The conductor which is ellent in wire drawing nature is excellent also in coil nature. this invention which consists of the drawing 6 (b) - a o a Cu-1 - 4.5%Ag alloy is super-thin -- a conductor -- the high conductivity more than 80%IACS -- it is -- 950-ϽN/mm2 It has high intensity and it turns out that it moreover excels in wire drawing nature and coil nature.

.8] (Example 2) wire drawing of the four following sorts of materials (Cu-2%Ag alloy) is carried out, and the ıeter of 25 micrometer is super-thin -- it considered as the conductor, the continuation wire drawing of this was ied out the speed for 400m/(67 g/hr) to the diameter of 20 micrometer, and total wire drawing time until it results in open circuit was investigated Moreover, the path of the foreign matter extracted in the foreign matter or acid tion process which remained in the fracture surface was measured by SEM observation. Both relation is shown in ving 7 . The continuation wire drawing of the three every bobbins each of the total wire drawing time was carried and it measured continuation wire drawing time until the 1st open circuit occurs for every bobbin, and made the total total wire drawing time. For example, total wire drawing time when the 1st bobbin is disconnected 5 hours r, the 2nd bobbin is disconnected 3 hours after and the 3rd bobbin is disconnected 4 hours after was made into 12 rs. Since the wire drawing time of one bobbin (the 2500g of the maximum ****) is 37 hours, the greatest total wire ving time is 111 hours. moreover, the aforementioned acid solution process is super-thin -- it is the method of pling 100g of conductors each from each five per one bobbin, and melting, filtering and extracting this in an acid A erial is the following four sorts. ** the rough drawing wire of 8mmphi manufactured by the SCR method, the uded material of 10mmphi manufactured by ** vertical-mold continuous casting and the extrusion method, and ** - ingot of 10mmphi usually cast using the small horizontal-type continuous casting equipment of a maintenance, ** -- the ingot (example of this invention) of 10mmphi which cast the molten metal which removed the foreign ter enough using small horizontal-type continuous casting equipment in the special molten metal treatment From ving 7 , total wire drawing time becomes so long that a foreign matter is small, ** material 10 micrometers or less the longest diameter of a foreign matter, and, as for ** to which the diameter of a foreign matter exceeds 10 rometers - ** material, wire drawing nature is short sharply. Although the aforementioned example explained the 2%Ag alloy, this invention is applied to a Cu-1 - 4.5%Ag alloy, and the same effect is acquired.

19] it rolled round in the bobbin (the diameter of 20 micrometer, the 2500g of the maximum ****) of the ementioned ** -- super-thin -- although coiling of the conductor (Cu-2%Ag alloy) was carried out with the omatic winding machine, the open circuit did not occur at all

20] it rolled round in the bobbin (the diameter of 20 micrometer, the 2500g of the maximum ****) of the ementioned ** -- super-thin -- the continuation wire drawing of the conductor was carried out to the diameter of 17 e micrometer, the foreign matter was extracted by the acid solution process like the above-mentioned from the ed-round bobbin, and the diameter of a foreign matter was measured by SEM observation Each diameter of a ign matter was 10 micrometers or less.

21] (Example 3) 2% or the copper alloy included 4% is ingoted for Ag, and a foreign matter is sedimented or risen urface -- making -- the molten metal of an interstitial segment -- small horizontal-type continuous casting ipment -- the ingot of the diameter of 10mm -- continuous casting -- carrying out -- this -- 50-15 micrometers -- er-thin -- wire drawing was carried out to the conductor The temperature gradient of the mold in the aforementioned tinuous casting was carried out [cm] in 100 degrees C /. The cast structure of the aforementioned ingot is detailed, S and Ag crystallization object are 15 micrometers or less, and Ag crystallization object was distributed uniformly. ingot which carried out [cm] the temperature gradient of mold in 50 degrees C /or less, and carried out continuous ting for comparison -- the same -- 50-15 micrometers -- super-thin -- wire drawing was carried out to the conductor s ingot had the comparatively coarse cast structure, and DAS and Ag crystallization object are 18 micrometers or re, and were distributing Ag crystallization object unevenly. it was obtained -- each -- super-thin -- wire drawing ıre (g/Br), tensile strength (TS), and conductivity (EC) were investigated about the conductor A result is shown in ole 1. In addition, wire drawing nature is a value when carrying out a continuation wire drawing to 190->50 rometers, 50->32 micrometers, 32->25 micrometers, 25->20 micrometers, and 20->15 micrometers, respectively.

22]

ble 1]

k	鋳塊からの冷間加工率%	x Cu-2%Ag 15≧DAS, Ag晶出物		y Cu-4%Ag 15≧DAS, Ag晶出物		z Cu-2%Ag 18≦DAS, Ag晶出物
n		伸線性	TS/EC	伸線性	TS/EC	伸線性
)	99.99750	⟩5000	1045/85.10	⟩5000	1095/82.35	4706
2	99.99897	⟩5000	1075/85.06	⟩5000	1125/82.27	4451
5	99.99937	3510	1090/85.00	3360	1140/82.15	1890
)	99.99960	2450	1095/84.96	2347	1150/82.11	730
5	99.99977	2275	1105/84.85	2153	1155/81.95	410

e) Wire drawing nature g/Br, TS(tensile strength)N/mm2, EC(conductivity) %IACS.
3] the cast structure was obtained from the detailed ingot so that more clearly than Table 1 -- super-thin -- luctor x and y were obtained from the ingot with the aforementioned comparatively coarse cast structure -- super- -- a conductor -- wire drawing nature was superior to z In addition, the main causes that the wire drawing nature of)ad at 25 micrometers or less are because casting conditions' being unsuitable and the external quality of a wire rod : bad. Although Ag was explained about 2% or the copper alloy included 4% above, also in Ag alloy, the same :t is acquired Cu-1 to 4.5%.
4] (Example 4) the Cu-2%Ag alloy of the diameter of 20 micrometer manufactured in the example 3 -- the enamel covered to Conductor x and z and the high-pressure uniformity test estimated the insulating property A high- sure uniformity test is an examination which impresses voltage between the enameled wire it runs, and an electrode and detects the poor insulation of an enameled wire by generating of a spark. The test condition was set to a part ravel-speed/of 5m of an enameled wire, and applied-voltage 500V. The examination number made the enameled with a length of 30m 30. The insulating property was expressed with the average spark occurrences per one. A lt is shown in Table 2.
5]
ıle 2]

ﾙ厚さ	6 μm	5 μm	4 μm	3 μm	2 μm	※鋳塊の鋳造組織
1のx	0	0	0	0	0．1	微細
1のz	0	0．03	0．1	0．7	1．4	比較的粗い

te) For *DAS and Ag crystallization object, 15 micrometers or less and Ag crystallization object are uniform :ibution.
DAS and Ag crystallization object, 18 micrometers or more and Ag crystallization object are uneven distribution.
26] super-thin -- insulating effect with Conductor x sufficient by the patent leather film thickness of 3 micrometers acquired since this is a cast structure with the used detailed ingot -- a conductor -- it is because the surface cavo-convex defect decreased super-thin -- a conductor -- since the used ingot was a comparatively coarse cast cture, z needed the patent leather film thickness of 6 micrometers or more to acquire sufficient insulating effect
27] the above -- super-thin -- it carried out 100 each at a time coiling of Conductor x and the enamel covered wire of the magnetic head for floppy disks with the automatic winding machine, and the number of times of an open circuit ıat time was investigated A result is shown in Table 3.
28]
ble 3]

ｴﾅﾒﾙ厚さ	6 μm	5 μm	4 μm	3 μm	2 μm	※鋳塊の鋳造組織
表1のx	0	0	0	0	0	微細
表1のz	0	0	1	2	2	比較的粗い

(Note) For *DAS and Ag crystallization object, 15 micrometers or less and Ag crystallization object are uniform distribution.
For DAS and Ag crystallization object, 18 micrometers or more and Ag crystallization object are uneven distributior
[0029] super-thin so that more clearly than Table 3 -- although Conductor x was not disconnected, it is super-thin -- : conductor -- the open circuit generated z in part DAS and Ag crystallization object are large and it is [the distributio of Ag crystallization object of this is uneven, and] super-thin again -- it is because the ductility of a conductor ran sh

[0030] (Example 5) the work-hardening curve b of the copper alloy cylindrical ingot of the diameter of 15mm which contains Ag shown in drawing 4 3%, and the work-hardening curve c (example of comparison) are super-thin -- the tensile strength (TS) of a conductor (37-8.3 micrometers) was investigated moreover -- each -- super-thin -- the enan was covered to the conductor at 3-micrometer thickness, and the number of times of an open circuit when carrying o coiling of this enamel covered wire with an automatic winding machine was investigated A result is shown in Table
[0031]
[Table 4]

導体径 μm		37	22	14	8.3
全加工歪 ε		12.0	13.0	14.0	15.0
全減面率 %		99.999391	99.999784	99.999912	99.999969
TS N/mm²	曲線b	1080	1115	1140	1150
	曲線c	875	930	984	1010
ｺｲﾘﾝｸﾞ時の断線回数	曲線b	0	0	0	0
	曲線c	1	2	2	3

[0032] the example of this invention is super-thin so that more clearly than Table 4 -- the example of comparison of conductor (curve b) is super-thin -- a conductor (curve c) -- tensile strength -- which conductor -- also in the path, it was high the example of comparison is super-thin -- since tensile strength of a conductor was low, the open circuit produced it at the time of coiling in an automatic winding machine Although the copper alloy which contains Ag 3% above was explained, the same effect is acquired even if it applies to the other Cu-1 - 4.5%Ag alloy.
[0033]
[Effect of the Invention] it stated above -- as -- the object for the coils of this invention -- super-thin -- a conductor consists silver of a copper alloy of optimum dose **** high intensity, and since the path of the foreign matter morec contained there is specified, it excels in wire drawing nature and coil nature the object for the coils of this invention super-thin -- a conductor can be easily manufactured by cold-working the ingot which specified crystallization **** DAS and Ag of a cast structure etc. by 99.997% or more of working ratio By putting in annealing at the temperature under a recrystallizing temperature in the middle of the aforementioned cold working, total working ratio can be enlarged and super-thin-izing of a conductor or enlargement of a material can be attained.

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:HNICAL FIELD

: technical field to which invention belongs] the object for coils which this invention is used for the coil of tronic equipment carried in the back light transformer of the vibrating motor for the stepping motor for clocks, the ;netic head of an audio video or a voice coil, a cellular phone, or pocket bells, various micro relays, a personal .puter, or television or a flyback transformer, and an automobile, and is excellent in conductivity, a mechanical)erty, wire drawing nature, coil nature, etc. -- super-thin -- it is related with a conductor and its manufacture method

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)R ART

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cription of the Prior Art] the object for coils -- super-thin -- a conductor is orthopedically operated by the magnetic after enamel covering etc. Although the tough pitch copper (TPC), the oxygen free copper (OFC), etc. are used for naterial, it is easy to disconnect these material in wire drawing or coil processing for low strength. If an open iit arises, a continuous wire drawing machine will be stopped, an open-circuit portion will be removed, the time effort of setting a wire rod to a dice and setting through and a dice to a wire drawing machine is required, and uctivity is injured. Moreover, if an open circuit arises, the defective by the shortage of a unit length will increase. eover, if wire drawing is performed through day and night and it disconnects at the night of a perfect non-human / system, a wire drawing machine will stop till the next morning, and productivity will fall sharply. Therefore, the ity conductor which is excellent in the wire drawing nature in which a continuation wire drawing is possible for 24 's is demanded. a miniaturization and lightweight-izing of recent years and electronic equipment -- following -- 20 'ometers or less -- super-thin -- although a conductor came to be required, incidentally, the amount of wire /ings when carrying out the continuation wire drawing of the conductor of the diameter of 20 micrometer the speed l00m/for 24 hours is 1610g, and when the safety factor is taken to 10%, the wire drawing nature of 1800 g/Br is led furthermore, a path is about 20 micrometers -- super-thin -- since a conductor fractures by the tension of several it disconnects by delicate change of a backward tension in an automatic winding machine In a manual winding hine, operation takes skill and there is a problem that it is inferior to productivity again.
)3] the object for coils since it is such -- super-thin -- the Cu-Ag system alloy which is excellent in intensity and luctivity as a conductor -- a close-up of a conductor was taken and the proposal of the following ** - ** was made l now However, in order that all may multiple-times need elevated-temperature annealing, including expensive Ag nuch, there is a problem in respect of cost and productivity. namely, the object for coils which prevented the open uit by the lubrication action of Ag which carries out pickling removal of the copper alternatively from the wire rod t face of the copper alloy which contains **Ag 5 to 15%, raises surface Ag concentration, performs repair of a ace blemish, and covering of a foreign matter by Enrichment Ag, and is further rich in ductility -- super-thin -- a luctor (JP,7-96321,A) ** the object for high magnetic field generating for magnets which made the copper alloy ch contains Ag 15 to 30% the cylindrical ingot of a minor diameter by the continuous casting process, and skipped process of hot forging and facing -- a conductor (JP,6-93398,A, JP,6-93399,A, JP,6-103809,A) ** The path which copper alloy ingot which contains Ag 15 to 30% was processed at 95% or more of working ratio, and it annealed th], it cold-worked [path] at the temperature more than a recrystallizing temperature after that, and recovered igation and conductivity is the conductor (JP,6-93398,A) of 0.1 or more mm. ** The conductor about [of having in annealing at the temperature more than a recrystallizing temperature, having cold-worked the copper alloy ingot ch contains Ag 15 to 30%, and having recovered conductivity] the diameter of 0.9mm (JP,6-93399,A). ** The luctor of the diameter of 0.1mm which processed the copper alloy ingot which contains Ag 15 to 30% by 95% or :e of working ratio, and annealed and cold-worked at the temperature more than a recrystallizing temperature after : (JP,6-103809,A). ** the metal mold of the copper alloy which contains Ag two to 2.8% -- the object for the marine cables of the diameter of 0.65mm which solution treatment of the ingot was carried out, the multiple-times p of the aging treatment was carried out to wire drawing after that, and intensity was raised, and omitted the nforcement iron braid of a cable -- a conductor (JP,48-44798,A)

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ECT OF THE INVENTION

ect of the Invention] it stated above -- as -- the object for the coils of this invention -- super-thin -- a conductor ists silver of a copper alloy of proper quantity **** high intensity, and since the path of the foreign matter eover contained there is specified, it excels in wire drawing nature and coil nature the object for the coils of this ntion -- super-thin -- a conductor can be easily manufactured by cold-working the ingot which specified :allization **** of DAS and Ag of a cast structure etc. by 99.997% or more of working ratio By putting in :aling at the temperature of under a recrystallizing temperature in the middle of the aforementioned cold working, working ratio can be enlarged and super-thin-izing of a conductor or enlargement of a material can be attained.

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HNICAL PROBLEM

ɔlem(s) to be Solved by the Invention] Then, this invention person etc. inquired wholeheartedly about application e coil of the copper alloy containing Ag, clarified the addition of Ag suitable for wire drawing nature and coil re, advances research about the tolerance limit of the cast structure which is further excellent in wire drawing re and coil nature, and foreign matter size etc., and came to complete this invention. the object for coils this ation excels [object] in conductivity, tensile strength, wire drawing nature, coil nature, etc. -- super-thin -- it aims fer of a conductor and its manufacture method

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ANS

ıns for Solving the Problem] as for invention according to claim 1, the remainder consists of Cu and an capable impurity, including Ag one to 4.5% of the weight (it is hereafter written as %) -- super-thin -- a conductor .s -- the above -- super-thin -- a conductor -- the object for coils characterized by the path of the foreign matter ained inside being below dmum -- super-thin -- it is a conductor However, d=0.63D+0.13 (the inside of a formula Ↄ are super-thin path mum of a conductor)

6] It is the manufacture method of a conductor. invention according to claim 2 performs cold working to the er alloy ingot which the remainder becomes from Cu and an unescapable impurity, including Ag one to 4.5% -- r-thin -- the aforementioned ingot the object for coils according to claim 1 to which the dendrite arm space of a structure is characterized by for 15 micrometers or less and Ag crystallization object distributing uniformly with a ıeter 15 micrometers or less, and performing the aforementioned cold working by 99.997% or more of working -- super-thin -- it is the manufacture method of a conductor

7] It is the manufacture method of a conductor. invention according to claim 3 performs cold working to the ·er alloy ingot which the remainder becomes from Cu and an unescapable impurity, including Ag one to 4.5% -- r-thin -- the aforementioned ingot the dendrite arm space of a cast structure -- 15 micrometers or less and Ag :allization object -- a diameter 15 micrometers or less -- uniform -- distributing -- the aforementioned cold working the way -- the object for coils according to claim 1 characterized by being alike and annealing at the temperature ıder a recrystallizing temperature -- super-thin -- it is the manufacture method of a conductor

8]

ɔodiments of the Invention] as for this invention, the remainder consists of Cu and an unescapable impurity, ıding Ag one to 4.5% -- super-thin -- a conductor -- the path of the foreign matter contained inside was specified w to dmum, and wire drawing nature and coil nature were raised -- super-thin -- it is a conductor However, 63D+0.13 (the inside of a formula and D are super-thin path mum of a conductor)

is invention, Ag of an alloy element is super-thin, without distributing in the shape of a staple fiber, and reducing luctivity not much -- the intensity of a conductor is raised, with wire drawing nature and coil nature are improved ɜss than 1%, the reason for specifying the content of Ag to 1 - 4.5% is because material cost becomes high, in luctivity's falling, if it is not fully improved but the aforementioned wire drawing nature and coil nature exceed 6. 1.5 - 4% of especially the content of Ag is desirable.

·9] The convention of the aforementioned diameter of a foreign matter was made based on the next experiment. ıely, by being made from the rough drawing wire (diameter of 8mm) of the Cu-2%Ag alloy manufactured by the . formula continuous casting machine, wire drawing of this was carried out to the conductor of the diameter of 100- ıicrometer, and the size of the foreign matter which remains in the fracture surface of the conductor disconnected at time was measured with the scanning electron microscope (SEM). The path of a foreign matter is 13 micrometers ıore in the conductor of 63 micrometers or more and the diameter of 20 micrometer at the conductor of the diameter 00 micrometer, and and the diameter d of permission of the foreign matter in the conductor of Path D it is shown in ving 1 -- as -- d=0.63D+0.13 being expressed with (1) formula -- clear -- carrying out -- this -- based on (1) ıula, for example, the diameter of 20 micrometer is super-thin -- in order to have carried out the wire drawing of the ductor by no disconnecting, it found out that what is necessary was just to set the diameter of a foreign matter to 12 rometers or less By another experiment, when made from the extruded material of a large-sized ingot, the same .lt was obtained. Moreover, it was checked that the relation between an open circuit and the diameter of a foreign ter etc. is the same also in a tough pitch copper (TPC) or an oxygen free copper (OFC). the above super-thin in the :ion of (1) formula -- the ratio of the cross section T of a conductor, and the cross section t of a foreign matter -- it ıes to be shown in drawing 2 and super-thin, when expressed with a relation with wire drawing nature (the amount /ire drawings until it results in an open circuit) t/T -- the area ratio (a foreign matter space factor is called hereafter)

ıe foreign matter occupied to a conductor is super-thin -- a conductor -- when it is about 40% and a foreign matter :e factor exceeds 40% regardless of

.0] When the aforementioned foreign matter was identified by the X-ray microanalyser (EPMA), they were mainly metallic inclusions, such as oxide particles, such as aluminum 2O3, SnO2, and CuO, and a carbide (SiC) particle. aforementioned foreign matter is mixed from the alumina system or silica system refractory material which stitutes ** which connects the fusion furnace which mainly serves as a path until it results [from the dissolution of pper alloy molten metal] in casting, a holding furnace, tundish, and these. In this invention, a foreign matter points the aforementioned nonmetallic inclusion which influences an open circuit. In addition, although metal inclusion, ı as Fe, Cr, and nickel, may mix from a processing fixture etc., these cannot cause easily an open circuit by most of small thing whose path is about several micrometers. In the case of a flat-like foreign matter, in this invention, the e of the shape of flat and an ellipse and the spherical of the configuration of a foreign matter are most, and in the : of the average of the maximum width and a total length over coupling faces, and an ellipse-like foreign matter, it ade as the average of a minor axis and a major axis, and the path of these foreign matters makes it an overall neter, when spherical.

11] Although, as for the conductor which processed the ingot (material) cast in the large-sized facility, foreign ter open circuits occur frequently from per diameter of 100 micrometer, the ingot (material) which cast by orming the usual maintenance is processible by no disconnecting to the diameter of 30 micrometer using a small zontal-type continuous casting facility. however, a path is [around 20 micrometers] super-thin -- in order to carry the wire drawing of the conductor by no disconnecting, for that, a foreign matter keeps calm not only the usual ntenance but a molten metal for a long time by carrying out to below the diameter of 10 micrometer desirably w the diameter of 12 micrometer, a heavy foreign matter is made to sediment to a blast furnace bottom, a light ign matter surfaces the surface of hot water, and the special molten metal treatment of casting a molten metal with foreign matters of an interstitial segment is needed If it does in this way, wire drawing will become possible to the neter grade of 17 micrometer. Since invention of a claim 2 and three publications does not perform hot working or ated-temperature annealing, there are few opportunities for the scale to mix as a foreign matter.

12] the object for coils to which the dendrite arm space (DAS) of a cast structure cold-works invention according to m 2 at 99.997% or more of working ratio using the ingot which 15 micrometers or less and Ag crystallization object ributed uniformly with the diameter 15 micrometers or less -- super-thin -- it is the manufacture method of a ductor the reason DAS specifies the aforementioned ingot to the cast structure distributed uniformly [15 rometers or less and Ag crystallization object] in a diameter 15 micrometers or less -- the cold-working nature of ngot -- improving -- moreover, a conductor -- it is for a surface concavo-convex defect to decrease and for pre-ılation nature to improve it is fully destroyed and the reason for specifying the working ratio of cold working to 997% or more has a super-thin cast structure -- Ag crystallization object distributed in an ingot is minutely ributed in the shape of a staple fiber -- the increase of the ductility of a conductor -- coiling -- a sex -- it is for roving

13] DAS becomes smaller [a small ingot with a larger cooling rate] depending on the cooling rate at the time of ten-metal solidification. That is, as shown in drawing 3 , DAS is a vertical-mold continuous casting ingot. 0mmphi) SCR ingot (100x50mm) Small horizontal-type continuous casting machine ingot A (10mmphi) It becomes ıll in order. When the size of an ingot is the same, DAS is dependent on the temperature gradient of mold. That is, in case of the ingot of a small horizontal-type continuous casting machine, DAS of the ingot A which set [cm] up the perature gradient of mold in 50 degrees C /is as large as 18 micrometers or more, and DAS of the ingot B which set n] up the temperature gradient of mold in 100 degrees C /is small at 15 micrometers or less. That is, DAS can ain the ingot of the cast structure which 15 micrometers or less and Ag crystallization object distributed uniformly h the diameter 15 micrometers or less by enlarging the temperature gradient of mold and casting it using small ld.

14] cold working [in / invention according to claim 2 / in invention according to claim 3] -- on the way -- the ect for coils which was alike, put in annealing at the temperature of under a recrystallizing temperature, and raised ıl working ratio -- super-thin -- it is the manufacture method of a conductor The effect by the aforementioned ıealing is concretely explained with reference to drawing 4 below. In drawing 4 , Curve a is the work-hardening perty of the copper alloy cylindrical ingot of the diameter of 15mm which contains Ag 3%. Ductility falls and wire wing becomes impossible while processing distortion epsilon shows the maximum intensity and carries out work tening of the curve a after that by 12. epsilon becomes a working limit by 13 (22 micrometers of wire sizes, 99978% of working ratio).

15] Curve b is a work-hardening property when epsilon anneals the material of Curve a at low temperature nparatively by the I point of 8.71. The maximum intensity of Curve b is of the same grade as the maximum intensity

ırve a, and epsilon at that time (epsilon 1) is increasing to 15 (5 micrometers of wire sizes, 99.999988% of ing ratio). The aforementioned annealing was performed by passing the inside of the annealing furnace with a h of 2m which made the interior 700-degree C inert gas atmosphere between ** the speed for 200m/. the tensile gth after annealing -- 985N/mm2 it is -- this intensity is intensity by which epsilon (epsilon 2) of Curve a is 'alent to 6, and a distortion elimination factor is 31%= [(epsilon1-epsilon2)/epsilon1 x100] The aforementioned e-strength 985N/mm2 When it applies to the static annealing softening property of drawing 5 , annealing between ** is equivalent to static annealing of 300 degree-Cx 1 hour, and is under a recrystallizing temperature. In ion, processing distortion epsilon of the material of Curve a of aforementioned drawing 5 is the static annealing ning property of the I point (wire-size 193micrometer, 99.98% of working ratio, tensile strength 1070N/mm2) of Thus, by putting in annealing at the temperature of under a recrystallizing temperature in the middle of cold ing, high intensity can be maintained and total working ratio can be raised. Therefore, a more nearly super-thin uctor is obtained, or the diameter of a material (ingot) can be enlarged, and productivity improves. the conductor h puts in annealing -- size (path) -- the wire drawing to the diameter of a target after annealing -- a conductor -- it sirable to select so that intensity may turn into the highest intensity in front of a working limit Since the mentioned annealing is performed at the low temperature of under a recrystallizing temperature, it is advantageous ergy. You may perform the aforementioned annealing repeatedly two or more times. Moreover, the direction ırmed with in-line is excellent in productivity rather than it carries out with outline. An effect with the same said of ı annealing is acquired.

5] Curve c is a work-hardening property when epsilon (epsilon 1) anneals the material of Curve a at an elevated erature (temperature more than a recrystallizing temperature) comparatively by the I point of 8.71. For the material ırve c, epsilon is 16.5 (4 micrometers of wire sizes, 99.999993% of working ratio). It has disconnected and the cing strength is quite [material / of Curves a and b] a low. The material of this curve c has [that it is easy to nnect intensity with an automatic winding machine for a low reason] bad coiling nature. Although wire drawing e material of this curve c was carried out several times using various wire drawing machines, each disconnected it e and after 4 micrometers. That is, 4 micrometers is a wire drawing limitation. Whatever the material, the uctor of a wire drawing limitation should avoid use. Annealing of the material of Curve c was performed by ng the inside of the annealing furnace with a length of 2m which made the interior 1000-degree C inert gas sphere between ** the speed for 150m/. the tensile strength after annealing -- 420N/mm2 it is -- this intensity is ntensity by which epsilon (epsilon 2) of Curve a is equivalent to 0.1, and a distortion elimination factor is 99%= ilon1-epsilon2)/epsilon1 x100] The aforementioned tensile strength 420N/mm2 When it applies to drawing 5 , aling between ****** is equivalent to static annealing of 500 degree-Cx 1 hour. It was checked that 'stallization is completed by microstructure observation.

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.MPLE

mple] An example explains this invention in detail below.
mple 1) various carries out amount combination of Ag within this invention convention at electrolytic copper, this goted with a graphite crucible, it casts in metal mold to the ingot of the diameter of 10mm, and the diameter of 20 ometer is super-thin in this ingot -- wire drawing (99.9996% of working ratio) was carried out to the conductor it obtained -- each -- super-thin -- the relation of tensile strength (TS), conductivity (EC), wire drawing nature, coil re, and wire drawing nature and coil nature was investigated about the conductor similarly super-thin [about the Ag alloy and oxygen free copper of composition this invention convention outside] because of comparison -- the luctor was manufactured and the same investigation was conducted A result is shown in the drawing 6 (b) - a (e). relation between tensile strength and Ag content was shown in the drawing 6 (b). The example article of this ntion which contains Ag 1 to 4.5% is 2 940-1150Ns/mm. It turns out that it is high intensity. As for tensile ngth, Ag falls rapidly at less than 1%. The relation between conductivity and Ag content was shown in the drawing). It turns out that the example article of this invention which contains Ag 1 to 4.5% has the high conductivity of S 88.5 to 81.5%. If Ag exceeds 4.5%, conductivity will fall under to a specification value (81.5%). The relation veen the wire drawing nature (the amount of wire drawings per one open circuit) when carrying out a wire drawing e drawing 6 (**) from 25 micrometers at 20 micrometers and Ag content was shown. It turns out that the example le of this invention which contains Ag 1 to 4.5% has the high wire drawing nature of 1800 - 2500 g/Br. at less than the diameter of Ag of 20 micrometer is super-thin -- the wire drawing nature of 1800 g/Br required for the 24-hour inuation wire drawing of a conductor is not guaranteed The rapid fall of wire drawing nature whose Ag the rovement in the wire drawing nature in 1 - 3% is an effect by alloying, and exceeds 4.5% is based on the earance of an eutectic structure. The relation between coil nature and Ag content was shown in the drawing 6 (d). diameter of 20 micrometer of coil nature which carried out enamel covering is super-thin -- it expressed with the nber of times of an open circuit when carrying out coiling of the conductor with a manual winding machine or an matic winding machine, and producing the 100 magnetic heads There is [in an automatic winding machine / in a nual winding machine] all little number of times of an open circuit of the example of this invention which contains 1 to 4.5% 4 or less times at 1 or less time. Especially desirable Ag content seen from coil nature is 1.5 - 4%. They wire drawing nature (the amount of wire drawings per one open circuit), and coil nature (number of times of an n circuit under 100 coil production) to the drawing 6 (**). The relation was shown. The conductor which is ellent in wire drawing nature is excellent also in coil nature. this invention which consists of the drawing 6 (b) - a o a Cu-1 - 4.5%Ag alloy is super-thin -- a conductor -- the high conductivity more than 80%IACS -- it is -- 950-0N/mm2 It has high intensity and it turns out that it moreover excels in wire drawing nature and coil nature.
18] (Example 2) wire drawing of the four following sorts of materials (Cu-2%Ag alloy) is carried out, and the neter of 25 micrometer is super-thin -- it considered as the conductor, the continuation wire drawing of this was ied out the speed for 400m/(67 g/hr) to the diameter of 20 micrometer, and total wire drawing time until it results in open circuit was investigated Moreover, the path of the foreign matter extracted in the foreign matter or acid ution process which remained in the fracture surface was measured by SEM observation. Both relation is shown in wing 7 . The continuation wire drawing of the three every bobbins each of the total wire drawing time was carried and it measured continuation wire drawing time until the 1st open circuit occurs for every bobbin, and made the total total wire drawing time. For example, total wire drawing time when the 1st bobbin is disconnected 5 hours r, the 2nd bobbin is disconnected 3 hours after and the 3rd bobbin is disconnected 4 hours after was made into 12 rs. Since the wire drawing time of one bobbin (the 2500g of the maximum ****) is 37 hours, the greatest total wire wing time is 111 hours. moreover, the aforementioned acid solution process is super-thin -- it is the method of npling 100g of conductors each from each five per one bobbin, and melting, filtering and extracting this in an acid A erial is the following four sorts. ** the rough drawing wire of 8mmphi manufactured by the SCR method, the

extruded material of 10mmphi manufactured by ** vertical-mold continuous casting and the extrusion method, and ** - the ingot of 10mmphi usually cast using the small horizontal-type continuous casting equipment of a maintenance, and ** -- the ingot (example of this invention) of 10mmphi which cast the molten metal which removed the foreign matter enough using small horizontal-type continuous casting equipment in the special molten metal treatment From drawing 7 , total wire drawing time becomes so long that a foreign matter is small, ** material 10 micrometers or less has the longest diameter of a foreign matter, and, as for ** to which the diameter of a foreign matter exceeds 10 micrometers - ** material, wire drawing nature is short sharply. Although the aforementioned example explained the Cu-2%Ag alloy, this invention is applied to a Cu-1 - 4.5%Ag alloy, and the same effect is acquired.
[0019] it rolled round in the bobbin (the diameter of 20 micrometer, the 2500g of the maximum ****) of the aforementioned ** -- super-thin -- although coiling of the conductor (Cu-2%Ag alloy) was carried out with the automatic winding machine, the open circuit did not occur at all
[0020] it rolled round in the bobbin (the diameter of 20 micrometer, the 2500g of the maximum ****) of the aforementioned ** -- super-thin -- the continuation wire drawing of the conductor was carried out to the diameter of 1 more micrometer, the foreign matter was extracted by the acid solution process like the above-mentioned from the rolled-round bobbin, and the diameter of a foreign matter was measured by SEM observation Each diameter of a foreign matter was 10 micrometers or less.
[0021] (Example 3) 2% or the copper alloy included 4% is ingoted for Ag, and a foreign matter is sedimented or risen to surface -- making -- the molten metal of an interstitial segment -- small horizontal-type continuous casting equipment -- the ingot of the diameter of 10mm -- continuous casting -- carrying out -- this -- 50-15 micrometers -- super-thin -- wire drawing was carried out to the conductor The temperature gradient of the mold in the aforementioned continuous casting was carried out [cm] in 100 degrees C /. The cast structure of the aforementioned ingot is detailed DAS and Ag crystallization object are 15 micrometers or less, and Ag crystallization object was distributed uniformly the ingot which carried out [cm] the temperature gradient of mold in 50 degrees C /or less, and carried out continuous casting for comparison -- the same -- 50-15 micrometers -- super-thin -- wire drawing was carried out to the conductor This ingot had the comparatively coarse cast structure, and DAS and Ag crystallization object are 18 micrometers or more, and were distributing Ag crystallization object unevenly. it was obtained -- each -- super-thin -- wire drawing nature (g/Br), tensile strength (TS), and conductivity (EC) were investigated about the conductor A result is shown in Table 1. In addition, wire drawing nature is a value when carrying out a continuation wire drawing to 190->50 micrometers, 50->32 micrometers, 32->25 micrometers, 25->20 micrometers, and 20->15 micrometers, respectively.
[0022]
[Table 1]

導体径 μm	鋳塊からの冷間加工率%	x Cu-2%Ag 15≧DAS, Ag晶出物		y Cu-4%Ag 15≧DAS, Ag晶出物		z Cu-2%Ag 18≦DAS, Ag晶出物
		伸線性	TS/EC	伸線性	TS/EC	伸線性
50	99.99750	〉5000	1045/85.10	〉5000	1095/82.35	4706
32	99.99897	〉5000	1075/85.06	〉5000	1125/82.27	4451
25	99.99937	3510	1090/85.00	3360	1140/82.15	1890
20	99.99960	2450	1095/84.96	2347	1150/82.11	730
15	99.99977	2275	1105/84.85	2153	1155/81.95	410

(Note) Wire drawing nature g/Br, TS(tensile strength)N/mm2, EC(conductivity) %IACS.
[0023] the cast structure was obtained from the detailed ingot so that more clearly than Table 1 -- super-thin -- Conductor x and y were obtained from the ingot with the aforementioned comparatively coarse cast structure -- super thin -- a conductor -- wire drawing nature was superior to z In addition, the main causes that the wire drawing nature z is bad at 25 micrometers or less are because casting conditions' being unsuitable and the external quality of a wire r

bad. Although Ag was explained about 2% or the copper alloy included 4% above, also in Ag alloy, the same : is acquired Cu-1 to 4.5%.
l] (Example 4) the Cu-2%Ag alloy of the diameter of 20 micrometer manufactured in the example 3 -- the enamel :overed to Conductor x and z and the high-pressure uniformity test estimated the insulating property A high-ure uniformity test is an examination which impresses voltage between the enameled wire it runs, and an electrode and detects the poor insulation of an enameled wire by generating of a spark. The test condition was set to a part avel-speed/of 5m of an enameled wire, and applied-voltage 500V. The examination number made the enameled with a length of 30m 30. The insulating property was expressed with the average spark occurrences per one. A t is shown in Table 2.
5]
le 2]

ﾙ厚さ	6 μm	5 μm	4 μm	3 μm	2 μm	※鋳塊の鋳造組織
lのx	0	0	0	0	0. 1	微細
lのz	0	0. 03	0. 1	0. 7	1. 4	比較的粗い

e) For *DAS and Ag crystallization object, 15 micrometers or less and Ag crystallization object are uniform ibution.
DAS and Ag crystallization object, 18 micrometers or more and Ag crystallization object are uneven distribution.
.6] super-thin -- insulating effect with Conductor x sufficient by the patent leather film thickness of 3 micrometers acquired since this is a cast structure with the used detailed ingot -- a conductor -- it is because the surface :avo-convex defect decreased super-thin -- a conductor -- since the used ingot was a comparatively coarse cast :ture, z needed the patent leather film thickness of 6 micrometers or more to acquire sufficient insulating effect
!7] the above -- super-thin -- it carried out 100 each at a time coiling of Conductor x and the enamel covered wire of the magnetic head for floppy disks with the automatic winding machine, and the number of times of an open circuit ıat time was investigated A result is shown in Table 3.
!8]
ɔle 3]

ﾒﾙ厚さ	6 μm	5 μm	4 μm	3 μm	2 μm	※鋳塊の鋳造組織
:1のx	0	0	0	0	0	微細
:1のz	0	0	1	2	2	比較的粗い

ıte) For *DAS and Ag crystallization object, 15 micrometers or less and Ag crystallization object are uniform ribution.
DAS and Ag crystallization object, 18 micrometers or more and Ag crystallization object are uneven distribution.
29] super-thin so that more clearly than Table 3 -- although Conductor x was not disconnected, it is super-thin -- a .ductor -- the open circuit generated z in part DAS and Ag crystallization object are large and it is [the distribution \g crystallization object of this is uneven, and] super-thin again -- it is because the ductility of a conductor ran short

30] (Example 5) the work-hardening curve b of the copper alloy cylindrical ingot of the diameter of 15mm which ıtains Ag shown in drawing 4 3%, and the work-hardening curve c (example of comparison) are super-thin -- the sile strength (TS) of a conductor (37-8.3 micrometers) was investigated moreover -- each -- super-thin -- the enamel ; covered to the conductor at 3-micrometer thickness, and the number of times of an open circuit when carrying out ling of this enamel covered wire with an automatic winding machine was investigated A result is shown in Table 4.
31]
.ble 4]

導体径	μm	37	22	14	8.3
全加工歪	ε	12.0	13.0	14.0	15.0
全減面率	%	99.999391	99.999784	99.999912	99.999969
TS N/mm²	曲線b	1080	1115	1140	1150
	曲線c	875	930	984	1010
コイリング時の断線回数	曲線b	0	0	0	0
	曲線c	1	2	2	3

[0032] the example of this invention is super-thin so that more clearly than Table 4 -- the example of comparison of a conductor (curve b) is super-thin -- a conductor (curve c) -- tensile strength -- which conductor -- also in the path, it was high the example of comparison is super-thin -- for the low reason, the open circuit produced [tensile strength] conductor at the time of coiling in an automatic winding machine Although the copper alloy which contains Ag 3% above was explained, the same effect is acquired even if it applies to the other Cu-1 - 4.5%Ag alloy.

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)TICES *

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the drawings, any words are not translated.

ːCRIPTION OF DRAWINGS

ɜf Description of the Drawings]
wing 1] the diameter of a foreign matter about wire drawing nature, and a conductor -- it is drawing showing the ion of a path
wing 2] It is drawing showing the relation between wire drawing nature and a foreign matter space factor.
wing 3] It is drawing showing the relation between DAS and the diameter of an ingot.
wing 4] It is drawing showing the relation between tensile strength and processing distortion (work-hardening erty).
wing 5] It is drawing showing the relation between tensile strength and an annealing temperature (annealing ːning property).
wing 6] the object for the coils of this invention -- super-thin -- Ag content in a conductor, and tensile strength A nd conductivity A (b) and wire drawing nature A (c) and coil nature A relation with a (d), and relation between drawing nature and coil nature a (e) is shown -- it is each explanatory drawing
wing 7] the diameter of 20 micrometer is super-thin -- it is drawing showing the relation of the wire drawing nature the diameter of a foreign matter in a conductor

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ıWINGS

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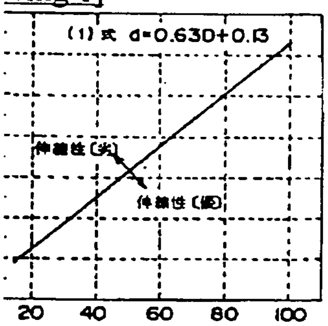
wing 1]



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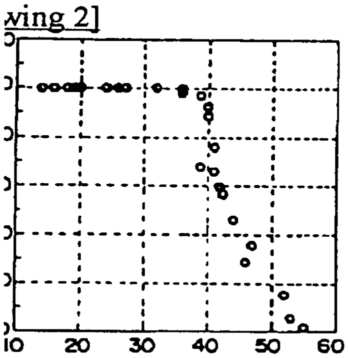

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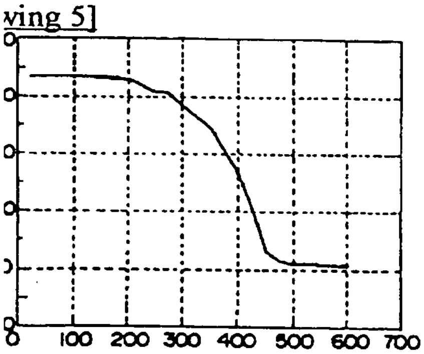

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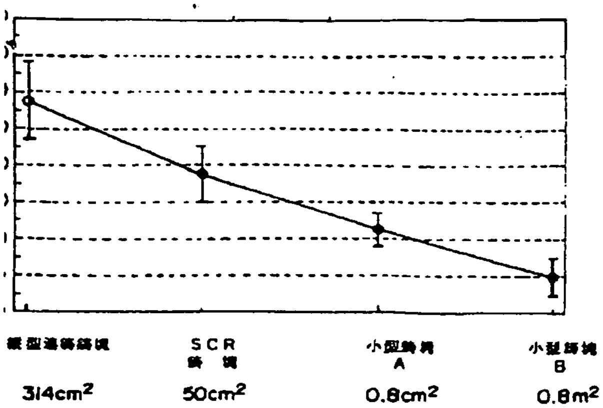

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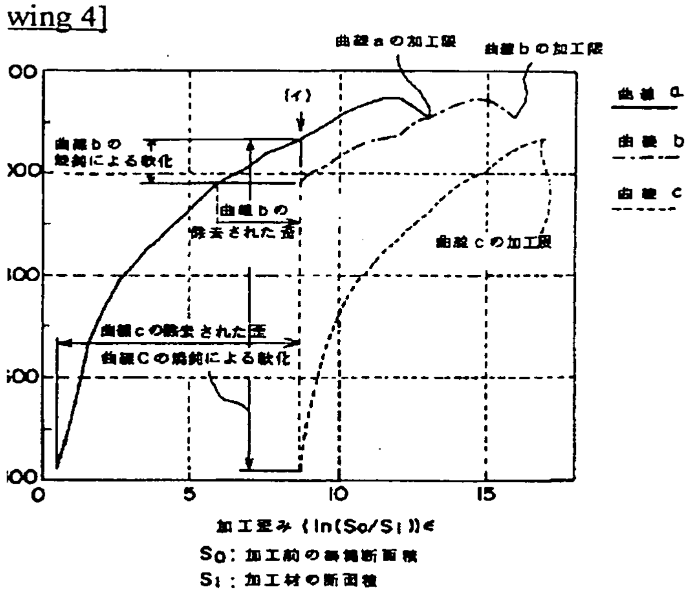

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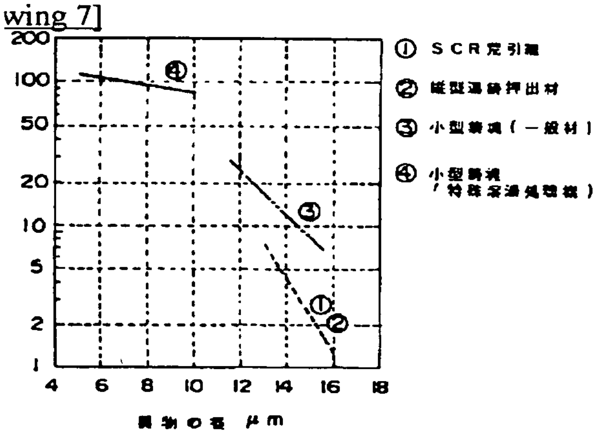

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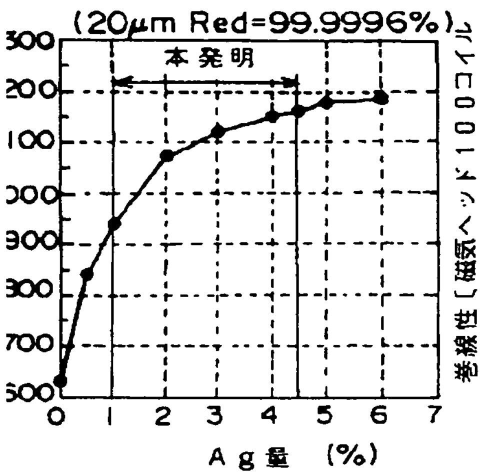

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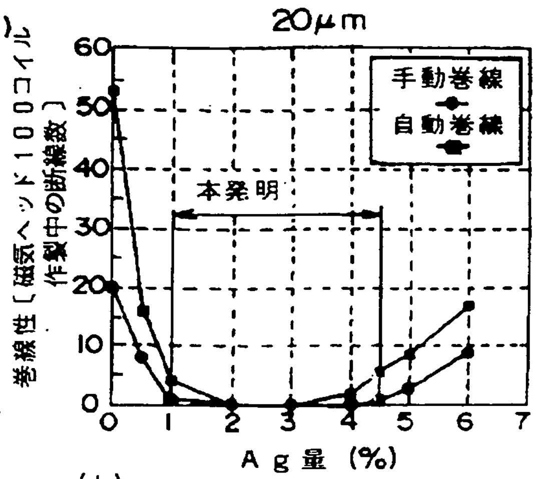

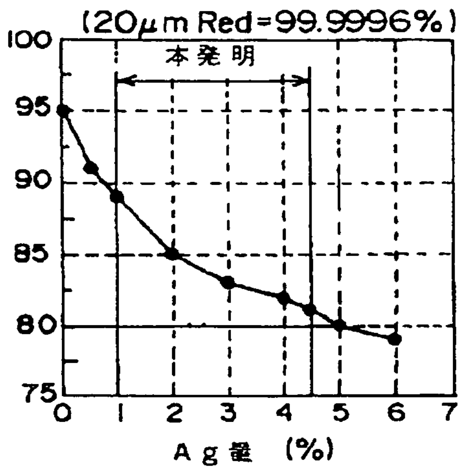

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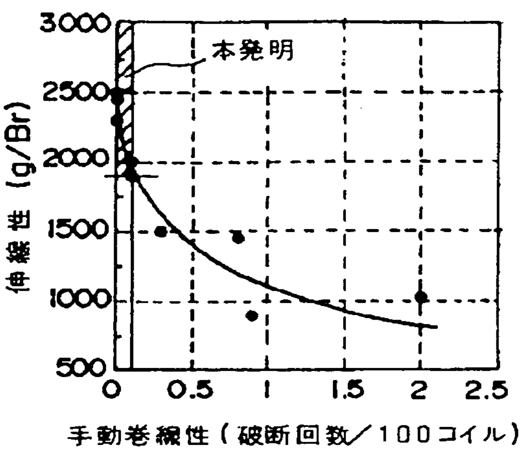

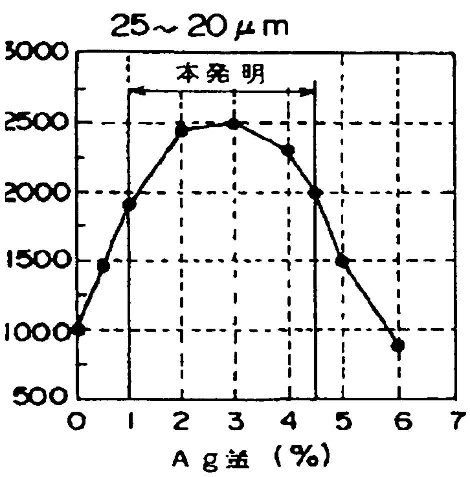

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Ｈ０１Ｂ	5/02		Ｈ０１Ｂ	5/02	Ｚ
	13/00	５０１		13/00	５０１Ｃ
// Ｃ２２Ｆ	1/00	６０１	Ｃ２２Ｆ	1/00	６０１

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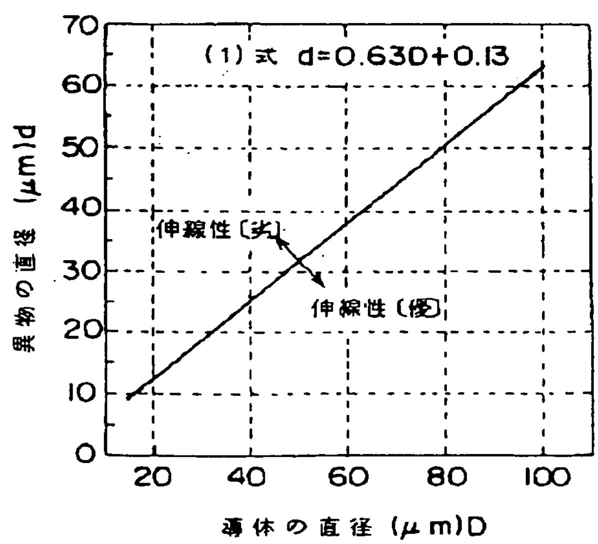
(54)【発明の名称】　巻線用極細導体およびその製造方法

(57)【要約】

【課題】　導電性、引張強度、伸線性、巻線性に優れる巻線用極細導体を提供する。

【解決手段】　Ａｇを１～４．５重量％（以下、％と略記する）含み、残部がＣｕと不可避不純物からなる極細導体であり、前記極細導体内に含まれる異物の径がｄμｍ以下の巻線用極細導体。但し、ｄ＝０．６３Ｄ＋０．１３（式中、Ｄは極細導体の径μｍ）

【効果】　銀を適量含む銅合金からなり、また導体に含まれる異物の径を所定値以下（極細導体との断面積比で４０％以下）に規定するので伸線性および巻線性に優れる。



【特許請求の範囲】
【請求項1】 Agを1～4．5重量％（以下、％と略記する）含み、残部がCuと不可避不純物からなる極細導体であり、前記極細導体内に含まれる異物の径がdμm以下であることを特徴とする巻線用極細導体。但し、d＝0．63D＋0．13（式中、Dは極細導体の径μm）
【請求項2】 Agを1～4．5％含み、残部がCuと不可避不純物からなる銅合金鋳塊に冷間加工を施す極細導体の製造方法であって、前記鋳塊は、鋳造組織のデンドライトアームスペースが15μm以下、Ag晶出物が15μm以下の径で均一に分散したものであり、前記冷間加工を99．997％以上の加工率で施すことを特徴とする請求項1記載の巻線用極細導体の製造方法。
【請求項3】 Agを1～4．5％含み、残部がCuと不可避不純物からなる銅合金鋳塊に冷間加工を施す極細導体の製造方法であって、前記鋳塊は、鋳造組織のデンドライトアームスペースが15μm以下、Ag晶出物が15μm以下の径で均一に分散したものであり、前記冷間加工の途中に再結晶温度未満の温度で焼鈍を施すことを特徴とする請求項1記載の巻線用極細導体の製造方法。
【発明の詳細な説明】
【0001】
【発明の属する技術分野】本発明は、時計用のステッピングモーター、オーディオ・ビデオの磁気ヘッドまたはボイスコイル、携帯電話やポケベル用の振動モーター、各種超小型リレー、パソコンやテレビのバックライトトランスまたはフライバックトランス、自動車に搭載する電子機器のコイルなどに使用され、導電性、機械的性質、伸線性、巻線性などに優れる巻線用極細導体およびその製造方法に関する。
【0002】
【従来の技術】巻線用極細導体はエナメル被覆後マグネットコイルなどに整形される。その材料にはタフピッチ銅（TPC）や無酸素銅（OFC）などが用いられているが、これら材料は、低強度のため伸線加工や巻線加工で断線し易い。断線が生じると、連続伸線機を停止し、断線部分を除去し、線材をダイスに通し、ダイスを伸線機にセットするという手間を要し生産性が害される。また断線が生じると単位長さ不足による不良品が増加する。また伸線加工は、昼夜を通して行われ、完全無人体制の夜間に断線すると伸線機は翌朝まで停止して生産性は大幅に低下する。そのため24時間連続伸線可能な伸線性に優れる高品質の導体が要求されている。近年、電子機器の小型化・軽量化に伴って20μm以下の極細導体が要求されるようになったが、因みに、20μm径の導体を400m／分の速度で24時間連続伸線するときの伸線量は1610gであり、安全係数を10％にとると1800g/Brの伸線性が必要になる。さらに、径が20μm程度の極細導体は数10グラムの張力で破断するため、自動巻線機では後方張力の微妙な変動によって断線する。手動巻線機では操作に熟練を要しまた生産性に劣るという問題がある。
【0003】このようなことから、巻線用極細導体として、強度と導電性に優れるCu－Ag系合金導体がクローズアップされ、これまでに下記①～⑥の提案がなされた。しかし、いずれも高価なAgを多量に含むか、高温焼鈍を複数回必要とするためコストおよび生産性の点で問題がある。即ち、①Agを5～15％含む銅合金の線材表面から銅を選択的に酸洗除去して表層のAg濃度を高め、富化Agにより表層の傷の補修と異物の被覆を行い、さらに延性に富むAgの潤滑作用で断線を防止した巻線用極細導体（特開平7-96321 号公報）。②Agを15～30％含む銅合金を連続鋳造法で小径の棒状鋳塊とし、熱間鍛造と面削の工程を省略した高磁界発生用マグネット用導体（特開平6-93398 号公報、特開平6-93399 号公報、特開平6-103809号公報）。③Agを15～30％含む銅合金鋳塊を加工率95％以上で加工し、その後再結晶温度以上の温度で焼鈍し冷間加工して伸びと導電性を回復させた径が0．1mm以上の導体（特開平6-93398 号公報）。④Agを15～30％含む銅合金鋳塊を再結晶温度以上の温度での焼鈍を入れて冷間加工して導電率を回復させた0．9mm径程度の導体（特開平6-93399 号公報）。⑤Agを15～30％含む銅合金鋳塊を95％以上の加工率で加工し、その後再結晶温度以上の温度で焼鈍して冷間加工した0．1mm径の導体（特開平6-103809号公報）。⑥Agを2～2．8％含む銅合金の金型鋳塊を溶体化処理し、その後伸線加工と時効処理を複数回繰返して強度を向上させてケーブルの補強鉄編組を省略した0．65mm径の海底ケーブル用導体（特開昭48-44798号公報）。
【0004】
【発明が解決しようとする課題】そこで、本発明者等は、Agを含む銅合金の巻線への適用について鋭意研究を行い、伸線性と巻線性に適したAgの添加量を明らかにし、さらに伸線性と巻線性に優れる鋳造組織、異物サイズの許容限度などについて研究を進めて本発明を完成させるに至った。本発明は、導電性、引張強度、伸線性、巻線性などに優れる巻線用極細導体およびその製造方法の提供を目的とする。
【0005】
【課題を解決するための手段】請求項1記載の発明は、Agを1～4．5重量％（以下、％と略記する）含み、残部がCuと不可避不純物からなる極細導体であり、前記極細導体内に含まれる異物の径がdμm以下であることを特徴とする巻線用極細導体である。但し、d＝0．63D＋0．13（式中、Dは極細導体の径μm）
【0006】請求項2記載の発明は、Agを1～4．5％含み、残部がCuと不可避不純物からなる銅合金鋳塊

に冷間加工を施す極細導体の製造方法であって、前記鋳塊は、鋳造組織のデンドライトアームスペースが15μm以下、Ag晶出物が15μm以下の径で均一に分散したものであり、前記冷間加工を99．997％以上の加工率で施すことを特徴とする請求項1記載の巻線用極細導体の製造方法である。

【0007】請求項3記載の発明は、Agを1～4．5％含み、残部がCuと不可避不純物からなる銅合金鋳塊に冷間加工を施す極細導体の製造方法であって、前記鋳塊は、鋳造組織のデンドライトアームスペースが15μm以下、Ag晶出物が15μm以下の径で均一に分散したものであり、前記冷間加工の途中に再結晶温度未満の温度で焼鈍を施すことを特徴とする請求項1記載の巻線用極細導体の製造方法である。

【0008】

【発明の実施の形態】本発明は、Agを1～4．5％含み、残部がCuと不可避不純物からなる極細導体内に含まれる異物の径をdμm以下に規定して伸線性および巻線性を向上させた極細導体である。但し、d＝0．63D＋0．13（式中、Dは極細導体の径μm）

本発明において、合金元素のAgは短繊維状に分散して、導電性を余り低下させることなく、極細導体の強度を高め、以て伸線性と巻線性を改善する。Agの含有量を1～4．5％に規定する理由は、1％未満では前記伸線性と巻線性が十分に改善されず、4．5％を超えると導電性が低下するうえ、材料コストが高くなるためである。Agの含有量は1．5～4％が特に望ましい。

【0009】前記異物径の規定は次の実験に基づいてなされた。即ち、SCR式連続鋳造機により製造されたCu－2％Ag合金の荒引線（8mm径）を素材として、これを100～20μm径の導体に伸線加工し、その際断線した導体の破面に残存する異物の大きさを走査電子顕微鏡（SEM）により測定した。そして、異物の径は、100μm径の導体で63μm以上、20μm径の導体で13μm以上であり、径Dの導体における異物の許容径dは、図1に示すように$d=0.63D+0.13$の (1)式で表されることを明らかにし、この (1)式を基に、例えば、20μm径の極細導体を無断線で伸線するには、異物径は12μm以下にすれば良いことを見いだした。別の実験により、大型鋳塊の押出材を素材とする場合も同じ結果が得られた。また断線と異物径の関係などはタフピッチ銅（TPC）や無酸素銅（OFC）においても同様であることが確認された。前記 (1)式の関係を極細導体の断面積Tと異物の断面積tとの比t／Tと、伸線性（断線に到るまでの伸線量）との関係で表すと図2に示すようになり、極細導体に占める異物の断面積比（以下、異物占積率と称す）は、断線時の極細導体径Dに関係なく約40％であり、異物占積率が40％を超えると断線が生じ易くなることが判る。

【0010】前記異物をX線マイクロアナライザー（EPMA）により同定したところ、主にAl_2O_3、SnO_2、CuOなどの酸化物粒子、炭化物（SiC）粒子、などの非金属介在物であった。前記異物は、主に、銅合金溶湯の溶解から鋳造に至るまでの経路となる溶解炉、保持炉、タンディッシュ、これらを繋ぐ樋などを構成するアルミナ系またはシリカ系耐火材から混入する。本発明において、異物とは、断線に影響する前記非金属介在物を指す。なお、Fe、Cr、Niなどの金属介在物が加工治具などから混入する場合があるが、これらは径が数μm程度の小さいものが殆どで断線の原因にはなり難いものである。本発明において、異物の形状は、偏平状、楕円状、球状が殆どであり、これら異物の径は、偏平状異物の場合は最大幅と最大長さの平均値、楕円状異物の場合は短径と長径の平均値、球状の場合は最大径とする。

【0011】大型設備で鋳造した鋳塊（素材）を加工した導体は100μm径あたりから異物断線が多発するが、小型の横型連続鋳造設備を用い通常のメンテナンスを行って鋳造した鋳塊（素材）は、30μm径まで無断線で加工できる。しかし径が20μm前後の極細導体を無断線で伸線するには、異物は12μm径以下、望ましくは10μm径以下にする必要があり、そのためには、通常のメンテナンスだけでなく、例えば、溶湯を長時間鎮静して重い異物は炉底に沈降させ、軽い異物は湯面に浮上させ、中間部分の異物の少ない溶湯を鋳造するなどの特殊な溶湯処理が必要になる。このようにすれば17μm径程度まで伸線加工が可能になる。請求項2、3記載の発明は、熱間加工或いは高温焼鈍を行わないので、酸化スケールが異物として混入する機会が少ない。

【0012】請求項2記載の発明は、鋳造組織のデンドライトアームスペース（DAS）が15μm以下、Ag晶出物が15μm以下の径で均一に分散した鋳塊を用い、加工率99．997％以上で冷間加工する巻線用極細導体の製造方法である。前記鋳塊を、DASが15μm以下、Ag晶出物が15μm以下の径で均一に分散する鋳造組織に規定する理由は、鋳塊の冷間加工性が向上し、また導体表面の凹凸欠陥が減少して絶縁被覆性が向上するためである。冷間加工の加工率を99．997％以上に規定する理由は、鋳塊中に分散するAg晶出物が短繊維状に微細に分散されるなど鋳造組織が十分に破壊されて極細導体のしなやかさが増しコイリング性が向上するためである。

【0013】DASは溶湯凝固時の冷却速度に依存し、冷却速度の大きい小型鋳塊ほど小さくなる。即ち、図3に示すようにDASは縦型連続鋳造鋳塊（200mmφ）、SCR鋳塊（100×50mm）、小型横型連続鋳造機鋳塊A（10mmφ）の順に小さくなる。鋳塊の大きさが同じ場合は、DASは鋳型の温度勾配に依存する。即ち、小型横型連続鋳造機の鋳塊の場合、鋳型の温度勾配を50℃／cmに設定した鋳塊AのDASは18

μm以上と大きく、鋳型の温度勾配を100℃／cmに設定した鋳塊BのDASは15μm以下に小さくなっている。つまり、DASが15μm以下、Ag晶出物が15μm以下の径で均一に分散した鋳造組織の鋳塊は、小型の鋳型を用い鋳型の温度勾配を大きくして鋳造することにより得ることができる。

【0014】請求項3記載の発明は、請求項2記載の発明における冷間加工の途中に再結晶温度未満の温度で焼鈍を入れてトータルの加工率を向上させた巻線用極細導体の製造方法である。以下に前記焼鈍による効果を図4を参照して具体的に説明する。図4において、曲線aは、Agを3％含む15mm径の銅合金棒状鋳塊の加工硬化特性である。曲線aは、加工歪みεが12で最大強度を示し、その後加工軟化するとともに延性が低下して伸線加工ができなくなる。εが13（線径22μm、加工率99.99978%）で加工限界となる。

【0015】曲線bは、曲線aの材料をεが8．71のイ点で比較的低温で焼鈍したときの加工硬化特性である。曲線bの最大強度は曲線aの最大強度と同程度で、そのときのε（ε_1）は15（線径5μm、加工率99.999988%）に増加している。前記焼鈍は、内部を700℃の不活性ガス雰囲気とした長さ2mの走間焼鈍炉内を200m／分の速度で通過させて行った。焼鈍後の引張強度は985N／mm^{2}であり、この強度は曲線aのε（ε_2）が6に相当する強度であり、歪み除去率は31％＝〔（$\varepsilon_1-\varepsilon_2$）／$\varepsilon_1$×100〕である。前記強度985N／mm^{2}を、図5の静的焼鈍軟化特性に当てはめると、前記走間焼鈍は300℃×1時間の静的焼鈍に相当し、再結晶温度未満である。なお、前記図5は、曲線aの材料の加工歪みεが8．71のイ点（線径 193μm、加工率99.98%、引張強度1070N/mm^2）の静的焼鈍軟化特性である。このように、冷間加工の途中に再結晶温度未満の温度で焼鈍を入れることにより、高強度を維持してトータル加工率を高めることができる。従って、より極細の導体が得られ、または素材（鋳塊）径を大きくできて生産性が向上する。焼鈍を入れる導体サイズ（径）は、焼鈍後の目標径までの伸線加工で導体強度が加工限界前の最高強度になるように選定するのが望ましい。前記焼鈍は再結晶温度未満の低温で行うのでエネルギー的に有利である。前記焼鈍は複数回繰り返し行っても良い。またインラインで行う方が、アウトラインで行うより生産性に優れる。バッチ焼鈍でも同様の効果が得られる。

【0016】曲線cは、曲線aの材料をε（ε_1）が8．71のイ点で比較的高温（再結晶温度以上の温度）で焼鈍したときの加工硬化特性である。曲線cの材料はεが16．5（線径4μm、加工率99.999993%）で断線しており、その破断強度は曲線a、bの材料よりかなり低い。この曲線cの材料は強度が低いため自動巻線機で断線し易くコイリング性が悪い。この曲線cの材料は、種々の伸線機を用いて何回か伸線加工したが、いずれも4μm前後で断線した。つまり4μmが伸線加工限界である。伸線加工限界の導体は素材が何であれ使用を避けるべきである。曲線cの材料の焼鈍は、内部を1000℃の不活性ガス雰囲気とした長さ2mの走間焼鈍炉内を150m／分の速度で通過させて行った。焼鈍後の引張強度は420N／mm^{2}であり、この強度は曲線aのε（ε_2）が0．1に相当する強度で、歪み除去率は99％＝〔（$\varepsilon_1-\varepsilon_2$）／$\varepsilon_1$×100〕である。前記引張強度420N／mm^{2}を図5に当てはめると、前記走間焼鈍は500℃×1時間の静的焼鈍に相当する。ミクロ組織観察で再結晶が終了していることが確認された。

【0017】

【実施例】以下に本発明を実施例により詳細に説明する。

（実施例1）電気銅に本発明規定内でAgを種々の量配合し、これを黒鉛るつぼで溶製し、金型にて10mm径の鋳塊に鋳造し、この鋳塊を20μm径の極細導体に伸線加工（加工率99.9996%）した。得られた各極細導体について、引張強度（TS）、導電率（EC）、伸線性、巻線性、および伸線性と巻線性の関係を調べた。比較のため本発明規定外組成のCu－Ag合金および無酸素銅についても同様にして極細導体を製造し同じ調査を行った。結果を図6（イ）～（ホ）に示す。図6（イ）に引張強度とAg含有量との関係を示した。Agを1～4．5％含有する本発明例品は940～1150N／mm^{2}の高強度であることが判る。Agが1％未満で引張強度は急激に低下する。図6（ロ）に導電率とAg含有量との関係を示した。Agを1～4．5％含む本発明例品は88．5～81．5％IACSの高い導電率を有することが判る。Agが4．5％を超えると導電率は規格値（81．5％）未満に低下する。図6（ハ）に25μmから20μmに伸線するときの伸線性（1断線あたりの伸線量）とAg含有量との関係を示した。Agを1～4．5％含む本発明例品は1800～2500g/Brの高い伸線性を有することが判る。Agが1％未満では20μm径の極細導体の24時間連続伸線に必要な1800g/Brの伸線性が保証されない。Agが1～3％での伸線性の向上は合金化による効果であり、4．5％を超えての伸線性の急激な低下は共晶組織の出現によるものである。図6（ニ）に巻線性とAg含有量との関係を示した。巻線性はエナメル被覆した20μm径の極細導体を手動巻線機または自動巻線機でコイリングして磁気ヘッドを100個作製したときの断線回数で表した。Agを1～4．5％含む本発明例の断線回数は、自動巻線機で4回以下、手動巻線機で1回以下でいずれも少ない。巻線性から見た特に望ましいAg含有量は1．5～4％である。図6（ホ）に伸線性（1断線あたりの伸線量）と巻線性(100コイル作製中の断線回数）との関係を示した。伸線性に優れる導体は巻線性にも優れている。図6

（イ）～（ホ）から、Ｃｕ－１～４．５％Ａｇ合金からなる本発明の極細導体は、８０％ＩＡＣＳ以上の高導電性で、９５０～１１５０N/mm^{2}の高強度を有し、しかも伸線性と巻線性に優れることが判る。

【００１８】（実施例２）下記４種の素材（Ｃｕ－２％Ａｇ合金）を伸線加工して２５μm径の極細導体とし、これを２０μm径まで４００ｍ／分（67ｇ／hr）の速度で連続伸線して、断線に到るまでのトータル伸線時間を調べた。また破面に残存した異物または酸溶解法にて採取した異物の径をＳＥＭ観察により測定した。両者の関係を図７に示す。トータル伸線時間は、各３ボビンづつ連続伸線し、１回目の断線が起きるまでの連続伸線時間をボビンごとに測定し、その合計をトータル伸線時間とした。例えば、第１ボビンが５時間後に断線し、第２ボビンが３時間後に断線し、第３ボビンが４時間後に断線した場合のトータル伸線時間は１２時間とした。１ボビン（最大巻量2500ｇ）の伸線時間は３７時間なので最大のトータル伸線時間は１１１時間である。また前記酸溶解法は極細導体を１ボビンあたり５か所から各１００ｇづつサンプリングし、これを酸に溶かし濾過して採取する方法である。素材は次の４種である。①ＳＣＲ方式で製造した８㎜φの荒引線、②縦型連鋳・押出方式で製造した１０㎜φの押出材、③通常メンテナンスの小型横型連続鋳造装置を用いて鋳造した１０㎜φの鋳塊、④特殊な溶湯処理で異物を十分除去した溶湯を小型横型連続鋳造装置を用いて鋳造した１０㎜φの鋳塊（本発明例）。図７より、トータル伸線時間は、異物が小さいほど長くなり、異物径が１０μm以下の④材が最も長く、異物径が１０μmを超える①～③材は伸線性が大幅に短くなっている。前記実施例ではＣｕ－２％Ａｇ合金について説明したが、本発明はＣｕ－１～４．５％Ａｇ合金に適用して同様の効果が得られる。

【００１９】前記④のボビン（20μm径、最大巻量2500ｇ）に巻取った極細導体（Ｃｕ－２％Ａｇ合金）を自動巻線機によりコイリングしたが、断線は全く起きなかった。

【００２０】前記④のボビン（20μm径、最大巻量2500ｇ）に巻取った極細導体をさらに１７μm径に連続伸線し、巻取ったボビンから前述と同じように酸溶解法により異物を採取し、異物径をＳＥＭ観察により測定した。異物径はいずれも１０μm以下であった。

【００２１】（実施例３）Ａｇを２％または４％含む銅合金を溶製し、異物を沈降または浮上させ、中間部分の溶湯を小型横型連続鋳造装置により１０ｍｍ径の鋳塊に連続鋳造し、これを５０～１５μｍの極細導体に伸線加工した。前記連続鋳造での鋳型の温度勾配は１００℃／ｃｍにした。前記鋳塊の鋳造組織は微細で、ＤＡＳおよびＡｇ晶出物は１５μｍ以下であり、Ａｇ晶出物は均一に分散していた。比較のため、鋳型の温度勾配を５０℃／ｃｍ以下にして連続鋳造した鋳塊についても同様に５０～１５μｍの極細導体に伸線加工した。この鋳塊は鋳造組織が比較的粗く、ＤＡＳ、Ａｇ晶出物とも１８μｍ以上で、Ａｇ晶出物は不均一に分散していた。得られた各々の極細導体について、伸線性（g/Br）、引張強度（ＴＳ）、導電率（ＥＣ）を調べた。結果を表１に示す。なお、伸線性は１９０→５０μｍ、５０→３２μｍ、３２→２５μｍ、２５→２０μｍ、２０→１５μｍにそれぞれ連続伸線したときの値である。

【００２２】

【表１】

導体径 μm	鋳塊からの冷間加工率％	x Cu-2%Ag 15≧DAS, Ag晶出物		y Cu-4%Ag 15≧DAS, Ag晶出物		z Cu-2%Ag 18≦DAS, Ag晶出物
		伸線性	TS/EC	伸線性	TS/EC	伸線性
５０	99.99750	＞5000	1045/85.10	＞5000	1095/82.35	4706
３２	99.99897	＞5000	1075/85.06	＞5000	1125/82.27	4451
２５	99.99937	3510	1090/85.00	3360	1140/82.15	1890
２０	99.99960	2450	1095/84.96	2347	1150/82.11	730
１５	99.99977	2275	1105/84.85	2153	1155/81.95	410

（注）伸線性g/Br、ＴＳ（引張強度）N/mm^2、ＥＣ（導電率）％IACS。

【００２３】表１より明らかなように、鋳造組織が微細な鋳塊から得られた極細導体ｘ、ｙは、前記鋳造組織が比較的粗い鋳塊から得られた極細導体ｚより伸線加工性が優れた。なお、ｚの伸線加工性が２５μｍ以下で悪い主な原因は鋳造条件が不適当なことと、線材の外部品質が悪かったためである。以上Ａｇを２％または４％含む

銅合金について説明したが、Ｃｕ－１～４．５％Ａｇ合金においても同様の効果が得られる。

【００２４】（実施例４）実施例３で製造した２０μｍ径のＣｕ－２％Ａｇ合金導体ｘ、ｚにエナメルを被覆してその絶縁特性を高圧均一性試験により評価した。高圧均一性試験は、走行するエナメル線と電極輪間に電圧を印加し、スパークの発生によりエナメル線の絶縁不良を検知する試験である。試験条件はエナメル線の走行速度５ｍ／分、印加電圧５００Ｖとした。試験本数は長さ３０ｍのエナメル線を３０本とした。絶縁特性は１本当たりの平均スパーク発生数で表した。結果を表２に示す。

【００２５】

【表２】

ｴﾅﾒﾙ厚さ	６μｍ	５μｍ	４μｍ	３μｍ	２μｍ	※鋳塊の鋳造組織
表１のｘ	０	０	０	０	０．１	微細
表１のｚ	０	０．０３	０．１	０．７	１．４	比較的粗い

（注）※ＤＡＳとＡｇ晶出物は１５μｍ以下、Ａｇ晶出物は均一分散。
ＤＡＳとＡｇ晶出物は１８μｍ以上、Ａｇ晶出物は不均一分散。

【００２６】極細導体ｘは３μｍのエナメル皮膜厚さで十分な絶縁効果が得られた。これは用いた鋳塊が微細な鋳造組織のため導体表面の凹凸欠陥が減少したためである。極細導体ｚは用いた鋳塊が比較的粗い鋳造組織のため十分な絶縁効果を得るのに６μｍ以上のエナメル皮膜厚さが必要であった。

【００２７】前記極細導体ｘ、ｚのエナメル被覆線を自動巻線機にてフロッピーディスク用磁気ヘッドに各々１００個づつコイリングし、そのときの断線回数を調べた。結果を表３に示す。

【００２８】

【表３】

ｴﾅﾒﾙ厚さ	６μｍ	５μｍ	４μｍ	３μｍ	２μｍ	※鋳塊の鋳造組織
表１のｘ	０	０	０	０	０	微細
表１のｚ	０	０	１	２	２	比較的粗い

（注）※ＤＡＳとＡｇ晶出物は１５μｍ以下、Ａｇ晶出物は均一分散。
ＤＡＳとＡｇ晶出物は１８μｍ以上、Ａｇ晶出物は不均一分散。

【００２９】表３より明らかなように、極細導体ｘは無断線であったが、極細導体ｚは一部に断線が発生した。これはＤＡＳとＡｇ晶出物が大きくまたＡｇ晶出物の分散が不均一で極細導体のしなやかさが不足したためである。

【００３０】（実施例５）図４に示したＡｇを３％含む１５ｍｍ径の銅合金棒状鋳塊の加工硬化曲線ｂと加工硬化曲線ｃ（比較例）の極細導体（３７～８．３μｍ）の引張強度（ＴＳ）を調べた。また各々の極細導体に３μｍ厚さにエナメルを被覆し、このエナメル被覆線を自動巻線機でコイリングしたときの断線回数を調べた。結果を表４に示す。

【００３１】

【表４】

導体径	μm	３７	２２	１４	８．３
全加工歪	ε	１２．０	１３．０	１４．０	１５．０
全減面率	%	99.999391	99.999784	99.999912	99.999969
ＴＳ N/mm²	曲線ｂ	１０８０	１１１５	１１４０	１１５０
	曲線ｃ	８７５	９３０	９８４	１０１０
ｺｲﾘﾝｸﾞ時の断線回数	曲線ｂ	0	0	0	0
	曲線ｃ	1	2	2	3

【００３２】表４より明らかなように、本発明例の極細導体（曲線ｂ）は、比較例の極細導体（曲線ｃ）より引張強度が、いずれの導体径においても高かった。比較例の極細導体は引張強度が低いため自動巻線機でのコイリング時に断線が生じた。以上Ａｇを３％含む銅合金について説明したが、それ以外のＣｕ－１～４．５％Ａｇ合金に適用しても同様の効果が得られる。

【００３３】

【発明の効果】以上に述べたように、本発明の巻線用極細導体は、銀を適量含む高強度の銅合金からなり、しかもそこに含まれる異物の径を規定するので伸線性および巻線性に優れる。本発明の巻線用極細導体は、鋳造組織のＤＡＳとＡｇの晶出物径などを規定した鋳塊を９９．９９７％以上の加工率で冷間加工することにより容易に製造できる。前記冷間加工の途中に再結晶温度未満の温度で焼鈍を入れることによりトータル加工率を大きくすることができ、導体の極細化または素材の大型化が図れる。

【図面の簡単な説明】

【図１】伸線性に関する異物径と導体径の関係を示す図である。

【図２】伸線性と異物占積率との関係を示す図である。

【図３】ＤＡＳと鋳塊径の関係を示す図である。

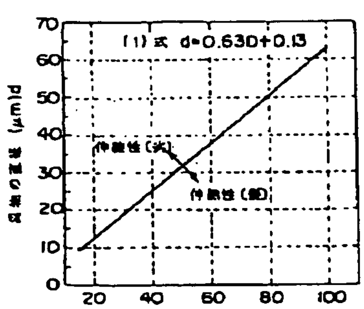
【図４】引張強度と加工歪みの関係（加工硬化特性）を示す図である。

【図５】引張強度と焼鈍温度の関係（焼鈍軟化特性）を示す図である。

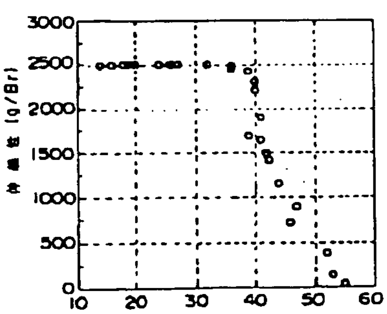
【図６】本発明の巻線用極細導体におけるＡｇ含有量と引張強度（ｲ）、導電率（ﾛ）、伸線性（ﾊ）、巻線性（ﾆ）との関係、および伸線性と巻線性の関係（ﾎ）を示すそれぞれ説明図である。

【図７】２０μｍ径の極細導体における伸線性と異物径との関係を示す図である。

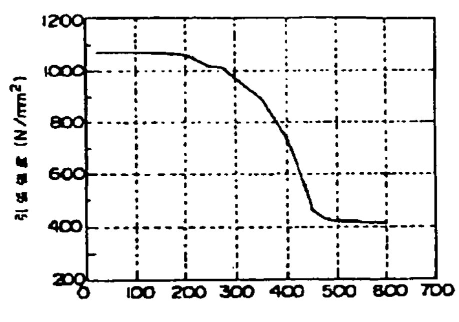
【図１】



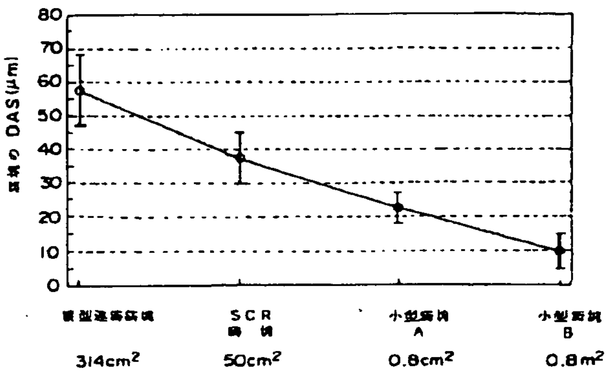
【図２】



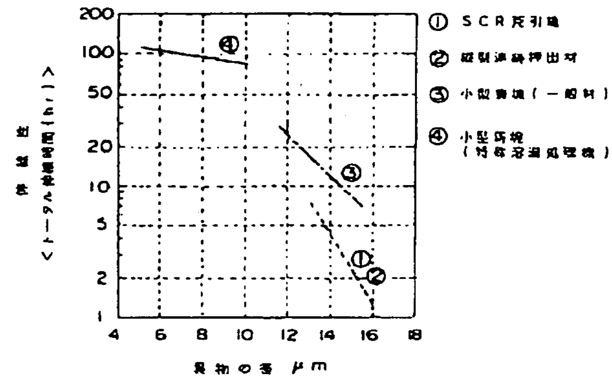
【図５】



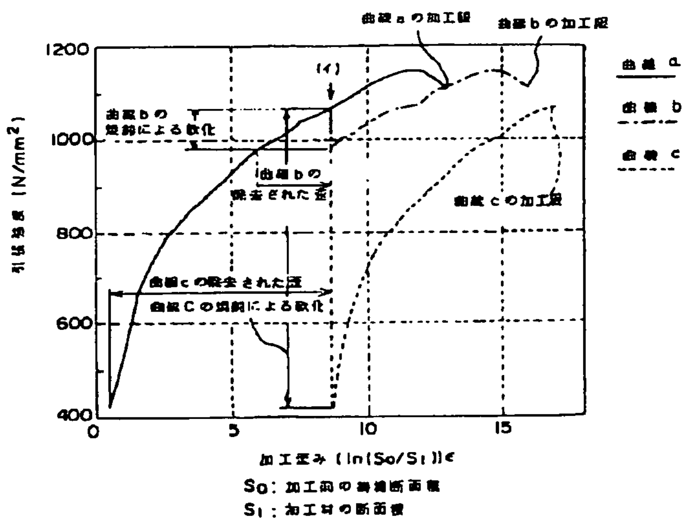
【図3】


80
70
60
50
40
30
20
10
0
鋳片の DAS(μm)
SCR
鋳片
小型鋳片
A
小型鋳片
B
314cm2
50cm2
0.8cm2
0.8m2

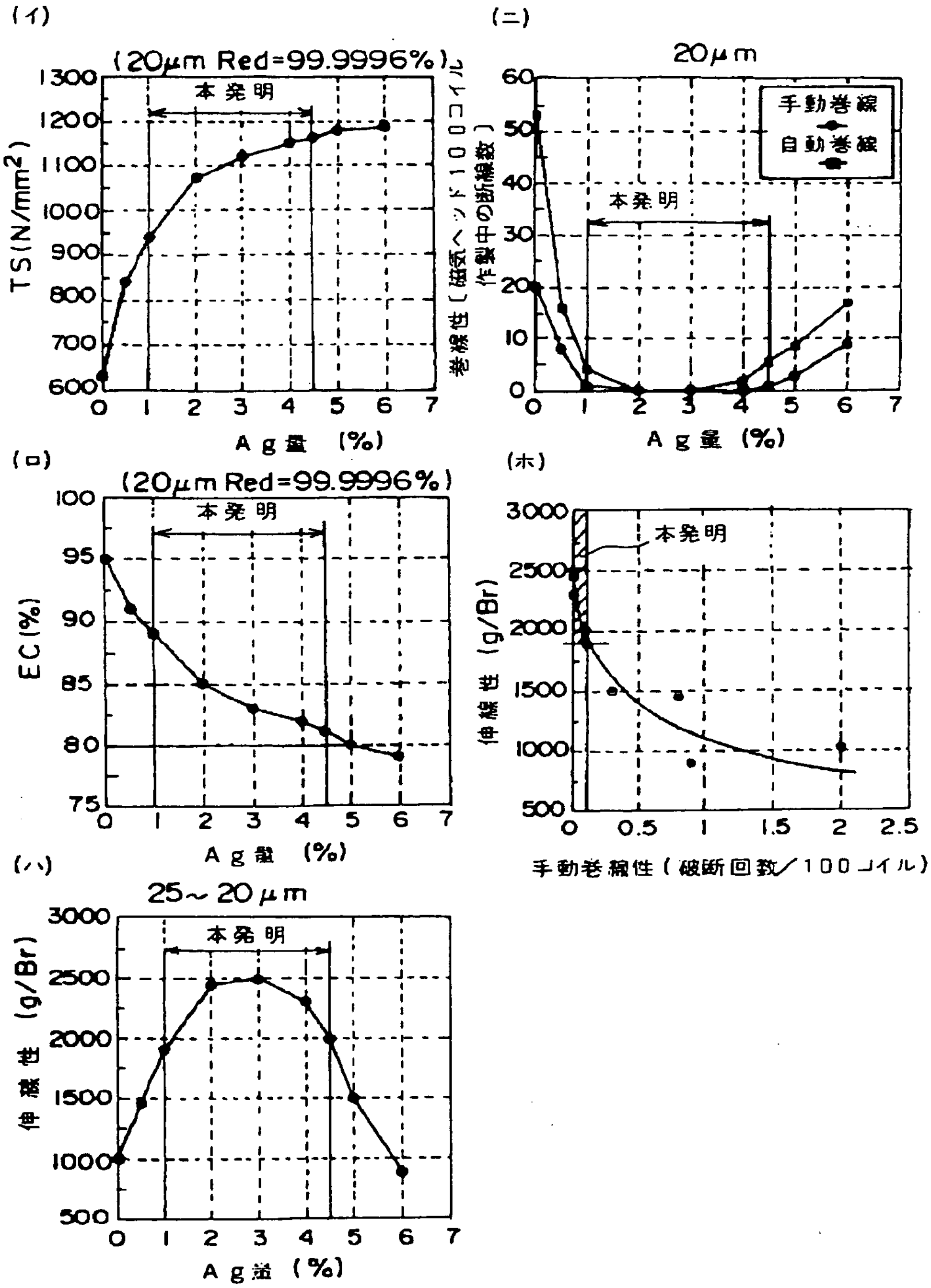
【図7】


200
100
50
20
10
5
2
1
4
6
8
10
12
14
16
18
μm
① SCR荒引線
③ 小型鋳塊（一般材）
④ 小型鋳塊

【図4】


1200
1000
800
600
400
0
5
10
15
(イ)
曲線 a
曲線 b
曲線 c
引張強度 (N/mm2)
加工歪み (ln(So/S1))ε
So: 加工前の鋳塊断面積
S1: 加工材の断面積

【図6】



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686	686Z
694	694A

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JP11293365

SUPER-FINE CONDUCTOR FOR WINDING, AND ITS MANUFACTURE

FURUKAWA ELECTRIC CO LTD:THE

Inventor(s): :YAMAZAKI AKIRA ;FUJIWARA HIDEMICHI ;ANDO MASAYUKI

Application No. 10096512 , Filed 19980409 , Published 19991026

Abstract:

PROBLEM TO BE SOLVED: To provide a conductor excellent in electric conductivity, tensile strength, drawability and coilability by containing foreign matters of specified diameters in a super-fine conductor containing Ag of a specified ratio, and the balance Cu with inevitable impurities.

SOLUTION: Ag of 1-4.5 wt.% is contained, and the diameter d (μm) of foreign matters is expressed by the formula d=0.63D+0.13, where D is the diameter (μm) of a super-fine conductor. In a manufacturing method of the super-fine conductor in which a copper alloy cast ingot preferably containing 1-4.5% Ag and the balance Cu with inevitable impurities is cold rolled, the cast ingot is cold rolled with the working ratio of 99.997% so that the dendrite arm space of the casting structure is 15 μm, and Ag crystal is uniformly dispersed with the diameter of 15 μm, or annealed at the temperature below the re- crystallization temperature during the cold rolling. The total working ratio can be increased to provide a super-fine conductor and to increase the size of a stock material.

Int'l Class: C22C00900 C22F00108 H01B00502 H01B01300 C22F00100 C22F00100 C22F00100 C22F00100 C22F00100 C22F00100 C22F00100

MicroPatent Reference Number: 000634675

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C22F	1/08		C22F	1/08	C
H01B	5/02		H01B	5/02	Z
	13/00	501		13/00	501C
// C22F	1/00	601	C22F	1/00	601

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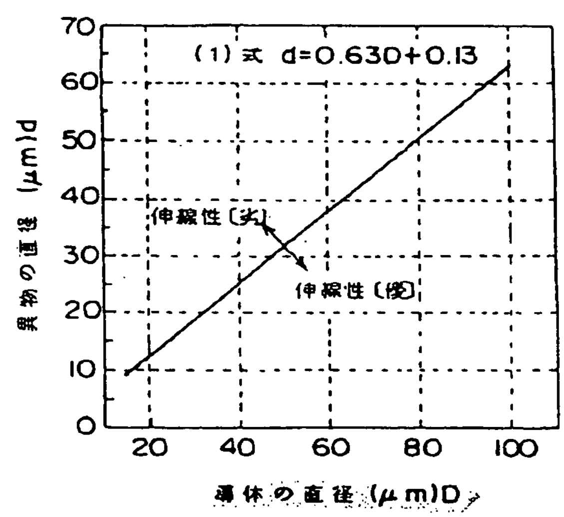
(54)【発明の名称】　巻線用極細導体およびその製造方法

(57)【要約】
【課題】　導電性、引張強度、伸線性、巻線性に優れる巻線用極細導体を提供する。
【解決手段】　Agを1～4．5重量％（以下、％と略記する）含み、残部がCuと不可避不純物からなる極細導体であり、前記極細導体内に含まれる異物の径がdμm以下の巻線用極細導体。但し、d＝0．63D＋0．13（式中、Dは極細導体の径μm）
【効果】　銀を適量含む銅合金からなり、また導体に含まれる異物の径を所定値以下（極細導体との断面積比で40％以下）に規定するので伸線性および巻線性に優れる。



【特許請求の範囲】

【請求項1】 Agを1～4．5重量％（以下、％と略記する）含み、残部がCuと不可避不純物からなる極細導体であり、前記極細導体内に含まれる異物の径がdμm以下であることを特徴とする巻線用極細導体。但し、d＝0．63D＋0．13（式中、Dは極細導体の径μm）

【請求項2】 Agを1～4．5％含み、残部がCuと不可避不純物からなる銅合金鋳塊に冷間加工を施す極細導体の製造方法であって、前記鋳塊は、鋳造組織のデンドライトアームスペースが15μm以下、Ag晶出物が15μm以下の径で均一に分散したものであり、前記冷間加工を99．997％以上の加工率で施すことを特徴とする請求項1記載の巻線用極細導体の製造方法。

【請求項3】 Agを1～4．5％含み、残部がCuと不可避不純物からなる銅合金鋳塊に冷間加工を施す極細導体の製造方法であって、前記鋳塊は、鋳造組織のデンドライトアームスペースが15μm以下、Ag晶出物が15μm以下の径で均一に分散したものであり、前記冷間加工の途中に再結晶温度未満の温度で焼鈍を施すことを特徴とする請求項1記載の巻線用極細導体の製造方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、時計用のステッピングモーター、オーディオ・ビデオの磁気ヘッドまたはボイスコイル、携帯電話やポケベル用の振動モーター、各種超小型リレー、パソコンやテレビのバックライトトランスまたはフライバックトランス、自動車に搭載する電子機器のコイルなどに使用され、導電性、機械的性質、伸線性、巻線性などに優れる巻線用極細導体およびその製造方法に関する。

【0002】

【従来の技術】巻線用極細導体はエナメル被覆後マグネットコイルなどに整形される。その材料にはタフピッチ銅（TPC）や無酸素銅（OFC）などが用いられているが、これら材料は、低強度のため伸線加工や巻線加工で断線し易い。断線が生じると、連続伸線機を停止し、断線部分を除去し、線材をダイスに通し、ダイスを伸線機にセットするという手間を要し生産性が害される。また断線が生じると単位長さ不足による不良品が増加する。また伸線加工は、昼夜を通して行われ、完全無人体制の夜間に断線すると伸線機は翌朝まで停止して生産性は大幅に低下する。そのため24時間連続伸線可能な伸線性に優れる高品質の導体が要求されている。近年、電子機器の小型化・軽量化に伴って20μm以下の極細導体が要求されるようになったが、因みに、20μm径の導体を400m／分の速度で24時間連続伸線するときの伸線量は1610gであり、安全係数を10％にとると1800g/Hrの伸線性が必要になる。さらに、径が20μm程度の極細導体は数10グラムの張力で破断するため、自動巻線機では後方張力の微妙な変動によって断線する。手動巻線機では操作に熟練を要しまた生産性に劣るという問題がある。

【0003】このようなことから、巻線用極細導体として、強度と導電性に優れるCu－Ag系合金導体がクローズアップされ、これまでに下記①～⑥の提案がなされた。しかし、いずれも高価なAgを多量に含むか、高温焼鈍を複数回必要とするためコストおよび生産性の点で問題がある。即ち、①Agを5～15％含む銅合金の線材表面から銅を選択的に酸洗除去して表層のAg濃度を高め、富化Agにより表層の傷の補修と異物の被覆を行い、さらに延性に富むAgの潤滑作用で断線を防止した巻線用極細導体（特開平7-96321 号公報）。②Agを15～30％含む銅合金を連続鋳造法で小径の棒状鋳塊とし、熱間鍛造と面削の工程を省略した高磁界発生用マグネット用導体（特開平6-93398 号公報、特開平6-93399 号公報、特開平6-103809号公報）。③Agを15～30％含む銅合金鋳塊を加工率95％以上で加工し、その後再結晶温度以上の温度で焼鈍し冷間加工して伸びと導電性を回復させた径が0．1mm以上の導体（特開平6-93398 号公報）。④Agを15～30％含む銅合金鋳塊を再結晶温度以上の温度での焼鈍を入れて冷間加工して導電率を回復させた0．9mm径程度の導体（特開平6-93399 号公報）。⑤Agを15～30％含む銅合金鋳塊を95％以上の加工率で加工し、その後再結晶温度以上の温度で焼鈍して冷間加工した0．1mm径の導体（特開平6-103809号公報）。⑥Agを2～2．8％含む銅合金の金型鋳塊を溶体化処理し、その後伸線加工と時効処理を複数回繰返して強度を向上させてケーブルの補強鉄編組を省略した0．65mm径の海底ケーブル用導体（特開昭48-44798号公報）。

【0004】

【発明が解決しようとする課題】そこで、本発明者等は、Agを含む銅合金の巻線への適用について鋭意研究を行い、伸線性と巻線性に適したAgの添加量を明らかにし、さらに伸線性と巻線性に優れる鋳造組織、異物サイズの許容限度などについて研究を進めて本発明を完成させるに至った。本発明は、導電性、引張強度、伸線性、巻線性などに優れる巻線用極細導体およびその製造方法の提供を目的とする。

【0005】

【課題を解決するための手段】請求項1記載の発明は、Agを1～4．5重量％（以下、％と略記する）含み、残部がCuと不可避不純物からなる極細導体であり、前記極細導体内に含まれる異物の径がdμm以下であることを特徴とする巻線用極細導体である。但し、d＝0．63D＋0．13（式中、Dは極細導体の径μm）

【0006】請求項2記載の発明は、Agを1～4．5％含み、残部がCuと不可避不純物からなる銅合金鋳塊

に冷間加工を施す極細導体の製造方法であって、前記鋳塊は、鋳造組織のデンドライトアームスペースが１５μｍ以下、Ａｇ晶出物が１５μｍ以下の径で均一に分散したものであり、前記冷間加工を９９．９９７％以上の加工率で施すことを特徴とする請求項１記載の巻線用極細導体の製造方法である。

【０００７】請求項３記載の発明は、Ａｇを１～４．５％含み、残部がＣｕと不可避不純物からなる銅合金鋳塊に冷間加工を施す極細導体の製造方法であって、前記鋳塊は、鋳造組織のデンドライトアームスペースが１５μｍ以下、Ａｇ晶出物が１５μｍ以下の径で均一に分散したものであり、前記冷間加工の途中に再結晶温度未満の温度で焼鈍を施すことを特徴とする請求項１記載の巻線用極細導体の製造方法である。

【０００８】

【発明の実施の形態】本発明は、Ａｇを１～４．５％含み、残部がＣｕと不可避不純物からなる極細導体内に含まれる異物の径をｄμｍ以下に規定して伸線性および巻線性を向上させた極細導体である。但し、ｄ＝０．６３Ｄ＋０．１３（式中、Ｄは極細導体の径μｍ）

本発明において、合金元素のＡｇは短繊維状に分散して、導電性を余り低下させることなく、極細導体の強度を高め、以て伸線性と巻線性を改善する。Ａｇの含有量を１～４．５％に規定する理由は、１％未満では前記伸線性と巻線性が十分に改善されず、４．５％を超えると導電性が低下するうえ、材料コストが高くなるためである。Ａｇの含有量は１．５～４％が特に望ましい。

【０００９】前記異物径の規定は次の実験に基づいてなされた。即ち、ＳＣＲ式連続鋳造機により製造されたＣｕ－２％Ａｇ合金の荒引線（８ｍｍ径）を素材として、これを１００～２０μｍ径の導体に伸線加工し、その際断線した導体の破面に残存する異物の大きさを走査電子顕微鏡（ＳＥＭ）により測定した。そして、異物の径は、１００μｍ径の導体で６３μｍ以上、２０μｍ径の導体で１３μｍ以上であり、径Ｄの導体における異物の許容径ｄは、図１に示すようにｄ＝0.63Ｄ＋0.13の（1）式で表されることを明らかにし、この（1)式を基に、例えば、２０μｍ径の極細導体を無断線で伸線するには、異物径は１２μｍ以下にすれば良いことを見いだした。別の実験により、大型鋳塊の押出材を素材とする場合も同じ結果が得られた。また断線と異物径の関係などはタフピッチ銅（ＴＰＣ）や無酸素銅（ＯＦＣ）においても同様であることが確認された。前記（1)式の関係を極細導体の断面積Ｔと異物の断面積ｔとの比ｔ／Ｔと、伸線性（断線に到るまでの伸線量）との関係で表すと図２に示すようになり、極細導体に占める異物の断面積比（以下、異物占積率と称す）は、断線時の極細導体径Ｄに関係なく約４０％であり、異物占積率が４０％を超えると断線が生じ易くなることが判る。

【００１０】前記異物をＸ線マイクロアナライザー（ＥＰＭＡ）により同定したところ、主にAl_2O_3、SnO_2、ＣｕＯなどの酸化物粒子、炭化物（ＳｉＣ）粒子、などの非金属介在物であった。前記異物は、主に、銅合金溶湯の溶解から鋳造に至るまでの経路となる溶解炉、保持炉、タンディッシュ、これらを繋ぐ樋などを構成するアルミナ系またはシリカ系耐火材から混入する。本発明において、異物とは、断線に影響する前記非金属介在物を指す。なお、Ｆｅ、Ｃｒ、Ｎｉなどの金属介在物が加工治具などから混入する場合があるが、これらは径が数μｍ程度の小さいものが殆どで断線の原因にはなり難いものである。本発明において、異物の形状は、偏平状、楕円状、球状が殆どであり、これら異物の径は、偏平状異物の場合は最大幅と最大長さの平均値、楕円状異物の場合は短径と長径の平均値、球状の場合は最大径とする。

【００１１】大型設備で鋳造した鋳塊（素材）を加工した導体は１００μｍ径あたりから異物断線が多発するが、小型の横型連続鋳造設備を用い通常のメンテナンスを行って鋳造した鋳塊（素材）は、３０μｍ径まで無断線で加工できる。しかし径が２０μｍ前後の極細導体を無断線で伸線するには、異物は１２μｍ径以下、望ましくは１０μｍ径以下にする必要があり、そのためには、通常のメンテナンスだけでなく、例えば、溶湯を長時間鎮静して重い異物は炉底に沈降させ、軽い異物は湯面に浮上させ、中間部分の異物の少ない溶湯を鋳造するなどの特殊な溶湯処理が必要になる。このようにすれば１７μｍ径程度まで伸線加工が可能になる。請求項２、３記載の発明は、熱間加工或いは高温焼鈍を行わないので、酸化スケールが異物として混入する機会が少ない。

【００１２】請求項２記載の発明は、鋳造組織のデンドライトアームスペース（ＤＡＳ）が１５μｍ以下、Ａｇ晶出物が１５μｍ以下の径で均一に分散した鋳塊を用い、加工率９９．９９７％以上で冷間加工する巻線用極細導体の製造方法である。前記鋳塊を、ＤＡＳが１５μｍ以下、Ａｇ晶出物が１５μｍ以下の径で均一に分散する鋳造組織に規定する理由は、鋳塊の冷間加工性が向上し、また導体表面の凹凸欠陥が減少して絶縁被覆性が向上するためである。冷間加工の加工率を９９．９９７％以上に規定する理由は、鋳塊中に分散するＡｇ晶出物が短繊維状に微細に分散されるなど鋳造組織が十分に破壊されて極細導体のしなやかさが増しコイリング性が向上するためである。

【００１３】ＤＡＳは溶湯凝固時の冷却速度に依存し、冷却速度の大きい小型鋳塊ほど小さくなる。即ち、図３に示すようにＤＡＳは縦型連続鋳造鋳塊（２００ｍｍφ）、ＳＣＲ鋳塊（１００×５０ｍｍ）、小型横型連続鋳造機鋳塊Ａ（１０ｍｍφ）の順に小さくなる。鋳塊の大きさが同じ場合は、ＤＡＳは鋳型の温度勾配に依存する。即ち、小型横型連続鋳造機の鋳塊の場合、鋳型の温度勾配を５０℃／ｃｍに設定した鋳塊ＡのＤＡＳは１８

μm以上と大きく、鋳型の温度勾配を100℃／cmに設定した鋳塊BのDASは15μm以下に小さくなっている。つまり、DASが15μm以下、Ag晶出物が15μm以下の径で均一に分散した鋳造組織の鋳塊は、小型の鋳型を用い鋳型の温度勾配を大きくして鋳造することにより得ることができる。

【0014】請求項3記載の発明は、請求項2記載の発明における冷間加工の途中に再結晶温度未満の温度で焼鈍を入れてトータルの加工率を向上させた巻線用極細導体の製造方法である。以下に前記焼鈍による効果を図4を参照して具体的に説明する。図4において、曲線aは、Agを3%含む15mm径の銅合金棒状鋳塊の加工硬化特性である。曲線aは、加工歪みεが12で最大強度を示し、その後加工軟化するとともに延性が低下して伸線加工ができなくなる。εが13（線径22μm、加工率99.99978%）で加工限界となる。

【0015】曲線bは、曲線aの材料をεが8．71のイ点で比較的低温で焼鈍したときの加工硬化特性である。曲線bの最大強度は曲線aの最大強度と同程度で、そのときのε（ε_1）は15（線径5μm、加工率99.999988%）に増加している。前記焼鈍は、内部を700℃の不活性ガス雰囲気とした長さ2mの走間焼鈍炉内を200m／分の速度で通過させて行った。焼鈍後の引張強度は985N／mm^{2}であり、この強度は曲線aのε（ε_2）が6に相当する強度であり、歪み除去率は31%＝〔（ε_1－ε_2）／ε_1×100〕である。前記強度985N／mm^{2}を、図5の静的焼鈍軟化特性に当てはめると、前記走間焼鈍は300℃×1時間の静的焼鈍に相当し、再結晶温度未満である。なお、前記図5は、曲線aの材料の加工歪みεが8．71のイ点（線径 193μm、加工率99.98%、引張強度1070N/mm^2）の静的焼鈍軟化特性である。このように、冷間加工の途中に再結晶温度未満の温度で焼鈍を入れることにより、高強度を維持してトータル加工率を高めることができる。従って、より極細の導体が得られ、または素材（鋳塊）径を大きくできて生産性が向上する。焼鈍を入れる導体サイズ（径）は、焼鈍後の目標径までの伸線加工で導体強度が加工限界前の最高強度になるように選定するのが望ましい。前記焼鈍は再結晶温度未満の低温で行うのでエネルギー的に有利である。前記焼鈍は複数回繰り返し行っても良い。またインラインで行う方が、アウトラインで行うより生産性に優れる。バッチ焼鈍でも同様の効果が得られる。

【0016】曲線cは、曲線aの材料をε（ε_3）が8．71のイ点で比較的高温（再結晶温度以上の温度）で焼鈍したときの加工硬化特性である。曲線cの材料はεが16．5（線径4μm、加工率99.999993%）で断線しており、その破断強度は曲線a、bの材料よりかなり低い。この曲線cの材料は強度が低いため自動巻線機で断線し易くコイリング性が悪い。この曲線cの材料は、種々の伸線機を用いて何回か伸線加工したが、いずれも4μm前後で断線した。つまり4μmが伸線加工限界である。伸線加工限界の導体は素材が何であれ使用を避けるべきである。曲線cの材料の焼鈍は、内部を1000℃の不活性ガス雰囲気とした長さ2mの走間焼鈍炉内を150m／分の速度で通過させて行った。焼鈍後の引張強度は420N／mm^{2}であり、この強度は曲線aのε（ε_3）が0．1に相当する強度で、歪み除去率は99%＝〔（ε_1－ε_3）／ε_1×100〕である。前記引張強度420N／mm^{2}を図5に当てはめると、前記走間焼鈍は500℃×1時間の静的焼鈍に相当する。ミクロ組織観察で再結晶が終了していることが確認された。

【0017】

【実施例】以下に本発明を実施例により詳細に説明する。

（実施例1）電気銅に本発明規定内でAgを種々の量配合し、これを黒鉛るつぼで溶製し、金型にて10mm径の鋳塊に鋳造し、この鋳塊を20μm径の極細導体に伸線加工（加工率99.9996%）した。得られた各極細導体について、引張強度（TS）、導電率（EC）、伸線性、巻線性、および伸線性と巻線性の関係を調べた。比較のため本発明規定外組成のCu－Ag合金および無酸素銅についても同様にして極細導体を製造し同じ調査を行った。結果を図6（イ）～（ホ）に示す。図6（イ）に引張強度とAg含有量との関係を示した。Agを1～4．5%含有する本発明例品は940～1150N／mm^{2}の高強度であることが判る。Agが1%未満で引張強度は急激に低下する。図6（ロ）に導電率とAg含有量との関係を示した。Agを1～4．5%含む本発明例品は88．5～81．5%IACSの高い導電率を有することが判る。Agが4．5%を超えると導電率は規格値（81．5%）未満に低下する。図6（ハ）に25μmから20μmに伸線するときの伸線性（1断線あたりの伸線量）とAg含有量との関係を示した。Agを1～4．5%含む本発明例品は1800～2500g/Brの高い伸線性を有することが判る。Agが1%未満では20μm径の極細導体の24時間連続伸線に必要な1800g/Brの伸線性が保証されない。Agが1～3%での伸線性の向上は合金化による効果であり、4．5%を超えての伸線性の急激な低下は共晶組織の出現によるものである。図6（ニ）に巻線性とAg含有量との関係を示した。巻線性はエナメル被覆した20μm径の極細導体を手動巻線機または自動巻線機でコイリングして磁気ヘッドを100個作製したときの断線回数で表した。Agを1～4．5%含む本発明例の断線回数は、自動巻線機で4回以下、手動巻線機で1回以下でいずれも少ない。巻線性から見た特に望ましいAg含有量は1．5～4%である。図6（ホ）に伸線性（1断線あたりの伸線量）と巻線性(100コイル作製中の断線回数）との関係を示した。伸線性に優れる導体は巻線性にも優れている。図6

(イ)～(ホ)から、Cu－1～4．5％Ag合金からなる本発明の極細導体は、80％IACS以上の高導電性で、950～1150N/mm² の高強度を有し、しかも伸線性と巻線性に優れることが判る。

【0018】(実施例2)下記4種の素材(Cu－2％Ag合金)を伸線加工して25μm径の極細導体とし、これを20μm径まで400m／分(67g／hr)の速度で連続伸線して、断線に到るまでのトータル伸線時間を調べた。また破面に残存した異物または酸溶解法にて採取した異物の径をSEM観察により測定した。両者の関係を図7に示す。トータル伸線時間は、各3ボビンづつ連続伸線し、1回目の断線が起きるまでの連続伸線時間をボビンごとに測定し、その合計をトータル伸線時間とした。例えば、第1ボビンが5時間後に断線し、第2ボビンが3時間後に断線し、第3ボビンが4時間後に断線した場合のトータル伸線時間は12時間とした。1ボビン(最大巻量2500g)の伸線時間は37時間なので最大のトータル伸線時間は111時間である。また前記酸溶解法は極細導体を1ボビンあたり5か所から各100gづつサンプリングし、これを酸に溶かし濾過して採取する方法である。素材は次の4種である。①SCR方式で製造した8mmφの荒引線、②縦型連鋳・押出方式で製造した10mmφの押出材、③通常メンテナンスの小型横型連続鋳造装置を用いて鋳造した10mmφの鋳塊、④特殊な溶湯処理で異物を十分除去した溶湯を小型横型連続鋳造装置を用いて鋳造した10mmφの鋳塊(本発明例)。図7より、トータル伸線時間は、異物が小さいほど長くなり、異物径が10μm以下の④材が最も長く、異物径が10μmを超える①～③材は伸線性が大幅に短くなっている。前記実施例ではCu－2％Ag合金について説明したが、本発明はCu－1～4．5％Ag合金に適用して同様の効果が得られる。

【0019】前記④のボビン(20μm径、最大巻量2500g)に巻取った極細導体(Cu－2％Ag合金)を自動巻線機によりコイリングしたが、断線は全く起きなかった。

【0020】前記④のボビン(20μm径、最大巻量2500g)に巻取った極細導体をさらに17μm径に連続伸線し、巻取ったボビンから前述と同じように酸溶解法により異物を採取し、異物径をSEM観察により測定した。異物径はいずれも10μm以下であった。

【0021】(実施例3)Agを2％または4％含む銅合金を溶製し、異物を沈降または浮上させ、中間部分の溶湯を小型横型連続鋳造装置により10mm径の鋳塊に連続鋳造し、これを50～15μmの極細導体に伸線加工した。前記連続鋳造での鋳型の温度勾配は100℃／cmにした。前記鋳塊の鋳造組織は微細で、DASおよびAg晶出物は15μm以下であり、Ag晶出物は均一に分散していた。比較のため、鋳型の温度勾配を50℃／cm以下にして連続鋳造した鋳塊についても同様に50～15μmの極細導体に伸線加工した。この鋳塊は鋳造組織が比較的粗く、DAS、Ag晶出物とも18μm以上で、Ag晶出物は不均一に分散していた。得られた各々の極細導体について、伸線性(g/Br)、引張強度(TS)、導電率(EC)を調べた。結果を表1に示す。なお、伸線性は190→50μm、50→32μm、32→25μm、25→20μm、20→15μmにそれぞれ連続伸線したときの値である。

【0022】

【表1】

導体径 μm	鋳塊からの冷間加工率％	x Cu-2%Ag 15≧DAS, Ag晶出物		y Cu-4%Ag 15≧DAS, Ag晶出物		z Cu-2%Ag 18≦DAS, Ag晶出物
		伸線性	TS/EC	伸線性	TS/EC	伸線性
50	99.99750	＞5000	1045/85.10	＞5000	1095/82.35	4706
32	99.99897	＞5000	1075/85.06	＞5000	1125/82.27	4451
25	99.99937	3510	1090/85.00	3360	1140/82.15	1890
20	99.99960	2450	1095/84.96	2347	1150/82.11	730
15	99.99977	2275	1105/84.85	2153	1155/81.95	410

(注)伸線性g/Br、TS(引張強度)N/mm²、EC(導電率)％IACS。

【0023】表1より明らかなように、鋳造組織が微細な鋳塊から得られた極細導体x、yは、前記鋳造組織が比較的粗い鋳塊から得られた極細導体zより伸線加工性が優れた。なお、zの伸線加工性が25μm以下で悪い主な原因は鋳造条件が不適当なことと、線材の外部品質が悪かったためである。以上Agを2％または4％含む

銅合金について説明したが、Ｃｕ－１～４．５％Ａｇ合金においても同様の効果が得られる。

【００２４】（実施例４）実施例３で製造した２０μm径のＣｕ－２％Ａｇ合金導体ｘ、ｚにエナメルを被覆してその絶縁特性を高圧均一性試験により評価した。高圧均一性試験は、走行するエナメル線と電極輪間に高圧を印加し、スパークの発生によりエナメル線の絶縁不良を検知する試験である。試験条件はエナメル線の走行速度５m／分、印加電圧５００Ｖとした。試験本数は長さ３０mのエナメル線を３０本とした。絶縁特性は１本当たりの平均スパーク発生数で表した。結果を表２に示す。

【００２５】

【表２】

ｴﾅﾒﾙ厚さ	６μm	５μm	４μm	３μm	２μm	※鋳塊の鋳造組織
表１のｘ	０	０	０	０	０．１	微細
表１のｚ	０	０．０３	０．１	０．７	１．４	比較的粗い

（注）※ＤＡＳとＡｇ晶出物は１５μm以下、Ａｇ晶出物は均一分散。
ＤＡＳとＡｇ晶出物は１８μm以上、Ａｇ晶出物は不均一分散。

【００２６】極細導体ｘは３μmのエナメル皮膜厚さで十分な絶縁効果が得られた。これは用いた鋳塊が微細な鋳造組織のため導体表面の凹凸欠陥が減少したためである。極細導体ｚは用いた鋳塊が比較的粗い鋳造組織のため十分な絶縁効果を得るのに６μm以上のエナメル皮膜厚さが必要であった。

【００２７】前記極細導体ｘ、ｚのエナメル被覆線を自動巻線機にてフロッピーディスク用磁気ヘッドに各々１００個づつコイリングし、そのときの断線回数を調べた。結果を表３に示す。

【００２８】

【表３】

ｴﾅﾒﾙ厚さ	６μm	５μm	４μm	３μm	２μm	※鋳塊の鋳造組織
表１のｘ	０	０	０	０	０	微細
表１のｚ	０	０	１	２	２	比較的粗い

（注）※ＤＡＳとＡｇ晶出物は１５μm以下、Ａｇ晶出物は均一分散。
ＤＡＳとＡｇ晶出物は１８μm以上、Ａｇ晶出物は不均一分散。

【００２９】表３より明らかなように、極細導体ｘは無断線であったが、極細導体ｚは一部に断線が発生した。これはＤＡＳとＡｇ晶出物が大きくまたＡｇ晶出物の分散が不均一で極細導体のしなやかさが不足したためである。

【００３０】（実施例５）図４に示したＡｇを３％含む１５mm径の銅合金棒状鋳塊の加工硬化曲線ｂと加工硬化曲線ｃ（比較例）の極細導体（３７～８．３μm）の引張強度（ＴＳ）を調べた。また各々の極細導体に３μm厚さにエナメルを被覆し、このエナメル被覆線を自動巻線機でコイリングしたときの断線回数を調べた。結果を表４に示す。

【００３１】

【表４】

導体径　μm		３７	２２	１４	８．３
全加工歪　ε		１２．０	１３．０	１４．０	１５．０
全減面率　%		99.999391	99.999784	99.999912	99.999969
ＴＳ N/mm²	曲線ｂ	１０８０	１１１５	１１４０	１１５０
	曲線ｃ	８７５	９３０	９８４	１０１０
コイリング時の断線回数	曲線ｂ	０	０	０	０
	曲線ｃ	１	２	２	３

【００３２】表４より明らかなように、本発明例の極細導体（曲線ｂ）は、比較例の極細導体（曲線ｃ）より引張強度が、いずれの導体径においても高かった。比較例の極細導体は引張強度が低いため自動巻線機でのコイリング時に断線が生じた。以上Ａｇを３％含む銅合金について説明したが、それ以外のＣｕ－１～４．５％Ａｇ合金に適用しても同様の効果が得られる。

【００３３】

【発明の効果】以上に述べたように、本発明の巻線用極細導体は、銀を適量含む高強度の銅合金からなり、しかもそこに含まれる異物の径を規定するので伸線性および巻線性に優れる。本発明の巻線用極細導体は、鋳造組織のＤＡＳとＡｇの晶出物径などを規定した鋳塊を９９．９９７％以上の加工率で冷間加工することにより容易に製造できる。前記冷間加工の途中に再結晶温度未満の温度で焼鈍を入れることによりトータル加工率を大きくすることができ、導体の極細化または素材の大型化が図れる。

【図面の簡単な説明】

【図１】伸線性に関する異物径と導体径の関係を示す図である。

【図２】伸線性と異物占積率との関係を示す図である。

【図３】ＤＡＳと鋳塊径の関係を示す図である。

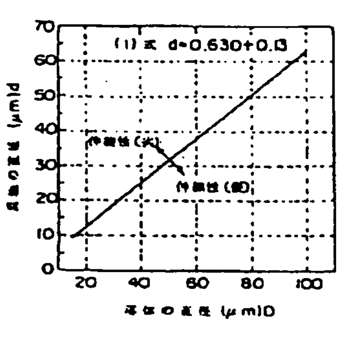
【図４】引張強度と加工歪みの関係（加工硬化特性）を示す図である。

【図５】引張強度と焼鈍温度の関係（焼鈍軟化特性）を示す図である。

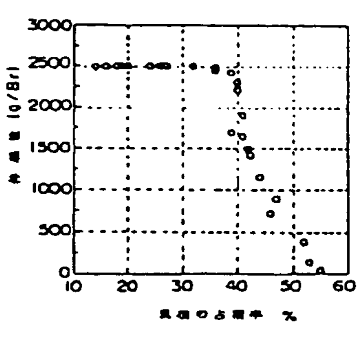
【図６】本発明の巻線用極細導体におけるＡｇ含有量と引張強度（ｲ）、導電率（ﾛ）、伸線性（ﾊ）、巻線性（ﾆ）との関係、および伸線性と巻線性の関係（ﾎ）を示すそれぞれ説明図である。

【図７】２０μｍ径の極細導体における伸線性と異物径との関係を示す図である。

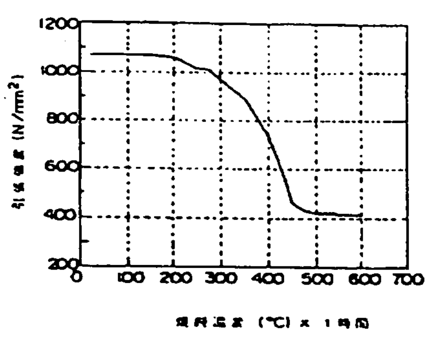
【図１】



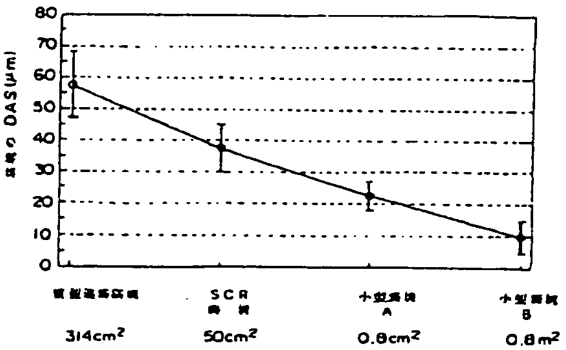
【図２】



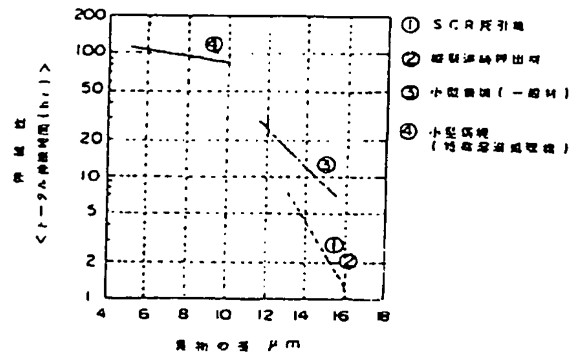
【図５】



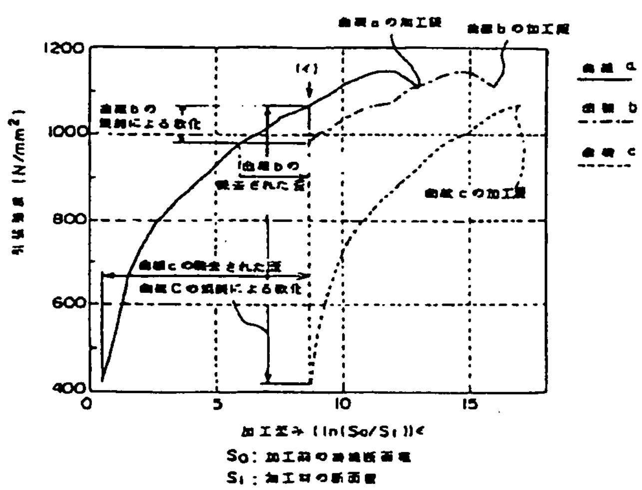
【図3】


DAS(μm)
80
70
60
50
40
30
20
10
0
SCR
A
B
314cm²
50cm²
0.8cm²
0.8m²

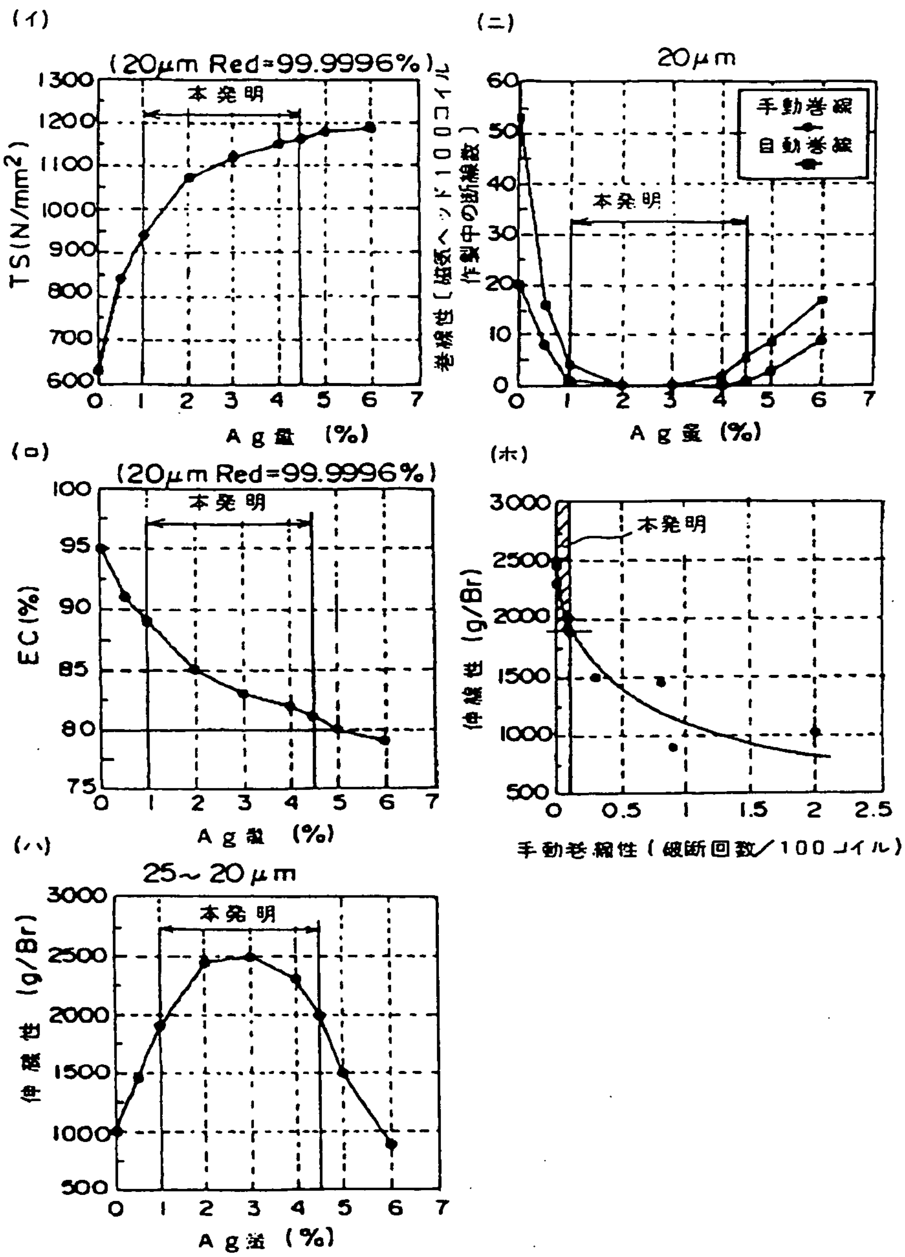
【図7】


200
100
50
20
10
5
2
1
4
6
8
10
12
14
16
18
μm
① SCR

【図4】


1200
1000
800
600
400
(N/mm²)
0
5
10
15
(ln(So/Si))
So:
Si:

【図6】



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